EPA/ROD/R04-99/136
1999

EPA Superfund
Record of Decision:

SAVANNAH RIVER SITE (USDOE)
EPA ID: SC1890008989
OU 55, 60, 65, 66
AIKEN, SC
09/28/1999

United States Department of Energy
Savannah River Site

OU-65, 55, 60 & 66
Plug-In Record of Decision for In Situ Stabilization With a Low Permeability Soil Cover System for Radiological Contaminants in Soil (U)

WSRC-RP-98-4099

Revision 0

September 1999

Prepared By:
Westinghouse Savannah River Company
Savannah River Company
Aiken, SC 29808

Prepared for the U.S. Department of Energy under Contract No. DE-AC09-96-SR18500

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In Situ Stabilization With a Low Permeability Soil Cover System for Radiological Contaminants in Soil (U)

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Savannah River Site
Aiken, South Carolina

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Savannah River Operations Office
Aiken, South Carolina

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DECLARATION FOR THE RECORD OF DECISION

Unit Name and Location

Savannah River Site
EPA ID #SC18000008989
Aiken, South Carolina

This plug-in record of decision (ROD) is designed to present a common remedy for high risk radioactively contaminated operable units (OUs) at (SRS) with similarities in history of use, contaminants, risk, and location in current industrial use areas adjacent to existing nuclear facilities. This approach has been developed by United States Environmental Protection Agency (US EPA) and successfully implemented at other superfund sites and is referred to as the plug-in approach. This ROD specifies the conditions that a specific operable unit shall meet in order to plug-in to this ROD and thus use the common remedy for remediation. A unit specific plug-in decision document will be used to demonstrate that an individual operable unit meets the criteria of this Plug-In ROD. By using the plug-in approach, remediation can begin earlier with a considerable cost savings, through reduction in documentation.

Candidate OUs, listed as "rad contaminated" Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) units in Appendix C of the Federal Facility Agreement (FFA) for SRS, may use this ROD if conditions exist which meet the plug-in criteria established within this ROD. If a candidate OU is to be plugged-in, this ROD will be modified through the issuance of an explanation of significant difference (ESD). The ESD will be-issued for public comment.

For those OUs where the plug-in ROD does not address all media included in the OU (e.g., groundwater, surface water, etc.), the plug-in ROD is an interim ROD that provides a final remedy for the source and does not impact the ability to remediate all additional media.. A final unit-specific ROD will be required for these OUs to complete remedial decision making, according to a schedule agreed upon by the United States Department of Energy (US DOE), US EPA, and South Carolina Department of Health and Environmental Concerns (SCDHEC) through the FFA. The plug-in ROD will be a final ROD for those OUs that only include the source term.

Statement of Basis and Purpose

This decision document presents the selected remedial alternative for applicable operable units that are located at SRS in Aiken, South Carolina. The selected alternative was developed in accordance with CERCLA, as amended, and to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). This decision was made considering the previous RODs for Old F-Area Seepage Basin (OFASB) and L-Area Oil and Chemical Basin (LAOCB) and on the Administrative Record File for the candidate operable units. The plug-in approach allows radiologically contaminated waste units that exhibit the appropriate criteria identified within this ROD to utilize the selected remedy.

Assessment of the Site

Candidate OUs are contaminated with radionuclides from past operations at SRS. The basins typically were used to dispose of radioactive process purge waters from the reactor disassembly basins, separation basins, and other similar basins, typically designed to allow the water to seep into the ground. Actual or threatened releases of hazardous substances from these sites, if not addressed by implementing the response action selected in this ROD, may present an imminent and substantial endangerment to public health, welfare, or the environment.

Description of the Selected Remedy

Based on the similar characteristics between the OFASB, the LAOCB, and preliminary candidate operable units (e.g., open reactor seepage basins), it is evident that use of a common remedy is appropriate. In situ stabilization with a low permeability soil cover system was selected as the remedial action for the OFASB and the LAOCB, and is selected as the plug-in ROD remedy.

The remedy consists of the following five aspects:

1) ***Institutional controls*** will consist of near- and long-term actions. Those actions will be consistent with industrial land use and the SRS Land Use Control Assurance Plan. For the near term, signs and existing SRS access controls will be used to prevent disturbance of the soil cover system. In the long term, if the property is ever transferred to nonfederal ownership, the U.S. Government will take those actions necessary pursuant to Section 120(h) of CERCLA, which will likely include deed restrictions precluding residential use or excavation within the boundaries of the unit.

2) ***Consolidation*** of contaminated soil outside the basins exceeding PTSM criteria, leachability RGs,s or surficial exposure RGs will occur. The soils will be excavated and placed into the primary discharge basin. Consolidated PTSM soil will be stabilized with the rest of the soil in that basin.

3) ***A low permeability soil cover system*** will be provided over the in situ stabilized soil to reduce water infiltration and to provide shielding to potential receptors on the surface. For basins that contain non-PTSM soil, but may leach contaminants to groundwater, a low permeability soil cover system will be placed over the soil. The soil cover system will be designed with permeability low enough to prevent migration of contaminants to groundwater for 1000 years at concentrations that will exceed MCLs.

4) ***In situ stabilization*** through grouting will be used to address PTSM soil in the basins which poses a risk in excess of 1 x 10^{-3} for future industrial workers. Stabilization treatment for this principal threat material is selected to meet the CERCLA preference for treatment. Stabilization treatment will provide for greater long-term effectiveness in protecting groundwater, and will also serve to augment prevention of potential direct exposure to the principal threat source material by converting the waste into a form less susceptible to uptake by human intruders.

5) ***Grouting*** will be used to stabilize any potential contamination left inside the pipeline and prevent access by small animals.

In situ stabilization with a low permeability soil cover system is the final action for the source term for each operable unit. This action will meet the following remedial action objectives:

1) Prevent human exposure to highly contaminated basin soils (PTSM) by performing stabilization treatment to the extent practicable and filling the basins. Reduce risks to the future worker from surface soils (0 to 0.3 m [0 to 1 ft]) outside the basin by establishing RGs for COCs at concentrations equivalent to 1 x 10^{-6} for carcinogens and a hazard quotient of 1 for noncarcinogens or background (where background levels of COCs exceed 1 x 10^{-6}).

2) Prevent the release of COCs in soil to groundwater beneath the unit above maximum contaminant levels (MCLs) or risk-based concentrations (when MCLs are not available). The soil RGs are back calculated based on these values.

3) Protect the ecological receptors indigenous to the area by preventing or limiting contact with contaminated basin soils and pipelines, and preventing the plant and animals from bringing contaminants up towards the surface.

The following specific criteria must be met before an operable unit can be considered for the plug-in ROD remedy:

- presence of elevated levels of radionuclides as primary soil contaminants,
- location in a current industrial use area (with buffer) adjacent to an existing nuclear facility,
- presence of principal threat source materials (PTSM), and
- PTSM not in direct contact with surface water or groundwater.

A technical evaluation report for each candidate OU must demonstrate that the OU meets these criteria and show how the remedy will be applied at that unit. An ESD will be issued and made available for public comment. The ESD will administratively select the plug-in remedy for the OU.

Statutory Determinations

The selected remedy is protective of human health and the environment, complies with federal and state requirements that are legally applicable or relevant and appropriate to the remedial action, and is cost-effective. This remedy utilizes permanent solutions and alternative treatment (or resource recovery) technology to the maximum extent practicable and satisfies the statutory preference for remedies that employ treatment to reduce toxicity, mobility, or volume as a principal element. The levels of radionuclides in the soil warrant a common remedy in which institutional controls is a required aspect of the remedy. In situ stabilization with a low permeability soil cover system is considered a short- and long-term permanent solution.

Section 300.430 (f)(4)(ii) of the National Oil and Hazardous Substances Pollution Contingency Plan requires that if hazardous substances, pollutants, or contaminants above levels that allow for unlimited use and unrestricted exposure remain in the waste operable unit, the action must be reviewed no less than every five years after its initiation. Because this remedy will result in hazardous substances remaining onsite above levels that allow for unlimited use and unrestricted exposure, the three parties (US DOE, SCDHEC, and US EPA) have determined that a five-year review of any decision made to use the plug-in interim ROD will be performed to ensure continued protection of human health and the environment.

Data Certification Checklist

This ROD is unique in that it does not identify a specific OU for the given remedial action. Rather, it selects a preferred remedy for OUs that meet the criteria specified in the ROD. The ROD provides the following information:

- COCs and their concentrations required (PTSM soil) to use the remedy
- Risks represented by the COCs
- Cleanup levels established for the COCs and the basis for the levels
- Current and future land use assumptions
- Land use that will be available at an OU as a result of the selected remedy
- Preliminary estimated capital, operation and maintenance, and total present worth cost
- Decision factors that lead to selecting the remedy

9/22/99
Date

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9/28/99
Date

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11/29/99
Date

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South Carolina Department of Health and Environmental Control

DECISION SUMMARY

Plug-In Record of Decision for
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Savannah River Site
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DECISION SUMMARY
TABLE OF CONTENTS

SECTION: **PAGE NO.**

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS AND ABBREVIATIONS

AOC	area of contamination
ARAR	applicable or relevant and appropriate requirement
bgs	below ground surface
C	Celsius
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
Ci	curie
cm	centimeter
cm/s	centimeter/second
COC	constituent of concern
CRSB	C-Area Reactor Seepage Basin
CSM	conceptual site model
ESD	Explanation of Significant Difference
F	Fahrenheit
FFA	Federal Facility Agreement
FS	Feasibility Study
ft	foot
in	inch
km.	kilometer
km^2	square kilometers
KRSB	K-Area Reactor Seepage Basin
LAOCB	L-Area Oil and Chemical Basin
LRSB	L-Area Reactor Seepage Basin
LUCAP	Land Use Control Assurance Plan
LUCIP	Land Use Control Implementation Plan
m	meter
MCL	maximum contaminant level
µg/L	microgram per liter
mi	mile
mi^2	square miles
msl	mean sea level
mrem	milliroentgen
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEPA	National Environmental Policy Act
NPL	National Priorities List
OFASB	Old F-Area Seepage Basin

OU	operable unit
pCi	picocuries
pCi/g	picocuries per gram
pCi/L	picocuries per liter
PP	proposed plan
PRSB	P-Area Reactor Seepage Basin
PTSM	principal threat source material
RAO	remedial action objective
RBC	risk-based concentration
RCRA	Resource Conservation and Recovery Act
RD/RA	remedial design/remedial action
RFI	RCRA Facility Investigation
RG	remedial goal
RI	remedial investigation
ROD	record of decision
SCDHEC	South Carolina Department of Health and Environmental Control
SLRG	soil leachability remedial goal
SRS	Savannah River Site
TBC	to be considered
USDA	United States Department of Agriculture
US DOE	United States Department of Energy
US EPA	United State Environmental Protection Aaency
WSRC	Westinghouse Savannah River Company

1.0 INTRODUCTION

The Savannah River Site (SRS), owned by the United States Department of Energy (US DOE), has historically produced tritium, plutonium, and other special nuclear materials for national defense and the space program. Wastes generated as by products from these processes are found in all of the nuclear and industrialized areas across SRS. Numerous waste units have been identified in the SRS Federal Facility Agreement (FFA 1993) between US DOE, the United States Environmental Protection Agency (US EPA), and the South Carolina Department of Health and Environmental Control (SCDHEC) and designated for investigation. Many of these waste units have similar, histories, contaminants, and environmental settings.

This record of decision (ROD) identifies in situ stabilization with a low permeability soil cover system as the preferred response action for radioactively contaminated source units that meet the specific criteria defined in this ROD. The remedy includes the use of institutional controls and allows for consolidation when appropriate. This conclusion was reached based on review of SRS decision precedents (i.e., previous RODs) and the evaluation of a centralized waste disposal facility; which together support the use of a plug-in approach. The plug-in approach is described below and specific sections of this ROD provide the rationale and justification for its application. Because US DOE, US EPA, and SCDHEC have agreed to the application of a plug-in approach toward remedy selection, this ROD may also be used as the decision basis for any unit at SRS that exhibits the specific unit characteristics described in this ROD.

1.1 Plug-in Approach Concept

Consistent with US EPA's presumptive remedy policy (US EPA 1993), which focuses on maximizing the administrative efficiency of the Comprehensive Environmental Response, Compensation & Liability Act (CERCLA) by utilizing similarities between operable units (OUs) to streamline remedial planning and implementation, the US DOE has adopted the use of plug-in approaches to OU remediation where there are recurrent problems warranting similar response

The plug-in approach identifies a preferred remedial action and then defines a process that will be used to determine where that remedial action shall be applied. US EPA,US DOE, and the U.S. Air Force used have plug-in approaches to accelerate remedial actions. Examples applications of plug-in approaches are presented below.

Examples of Plug-in Approaches	
1.	Indian Bend Wash Superfund Site (*Operable Unit Feasibility Study for VOCs in Vadose Zone, Indian Bend Wash Superfund Site, South Area; Tempe, Arizona; June 1993)* (US EPA 1994)
2.	Hanford Site 100 Area *USDOE Hanford 100 Area, Operable Units 100-BC-1, 100-DR-1, and 100-HR-1, EPA/ROD/R10-95/126*;(September 1995) (US EPA 1995a)
3.	Air Force PREECA *(United States Air Force Presumptive remedy Engineering Evaluation/Cost Analysis (PREECA); U.S. Army Corps of Engineers Omaha District* (May 5, 1995) (USCOE 1995)

This plug-in approach is consistent with the US DOE "Accelerating Cleanup: Focus On 2006" plan, as the approach would allow SRS to take final actions early at higher risk waste units to address source contamination. As a program management tool, this approach will allow appropriate decisions to be reached more efficiently and effectively, Specifically, the plug-in approach provides the following benefits:

! Evaluation of risk is focused on determining the need for action;
! Screening and evaluation of remedial alternatives are optimized;

- Documentation is streamlined and the time from characterization to remedial decision shortened;
- Remedial action decisions are made efficiently and consistently;
- Application of a common remedy allows for efficiencies in the remedial design and action phases

The plug-in approach is also consistent with the "Principles of Environmental Restoration" advocated by US DOE, US EPA, and SCDHEC. Table 1 identifies how the plug-in approach adheres to these principles.

The plug-in approach varies from the standard CERCLA process due primarily to the fact that the remedial decision making is initiated by defining the conditions for which a proven response is applicable and then identifying units that meet those conditions. Conversely, the standard CERCLA process would start with defining characteristics for a waste unit in a remedial investigation and then determining an appropriate response for those characteristics through a feasibility study (see Figure 1). Table 2 shows how the plug-in approach meets various CERCLA requirements.

This ROD will be applied to any OU exhibiting conditions that meet the plug-in criteria. This ROD defines what these conditions are and describes a process for determining whether they exist in a specific OU. When the conditions at an OU have been determined to match these predefined conditions, the OU will "plug-in" to the remedial action described in this plug-in ROD through a separate OU technical evaluation and explanation of significant difference (ESD). This decision framework and associated criteria for remedy selection were developed based on specific knowledge of a group of operable units.

Table 1. How the Application of the Plug-in Approach Meets the ER Principles

ER Principles	Application to this Plug-in Approach
Building an effective project / core team is essential.	This plug-in approach to decision making has been developed from the onset with the involvement of US DOE, US EPA and SCDHEC. All parties have participated in the conceptualization and subsequent documentation of this innovative approach. Further the plug-in ROD provides the framework that will be used to maintain the core team relationship for all current and future decisions made pursuant to this ROD.
Clear, concise, and accurate problem identification and definition are critical.	This ROD defines the common problem to be addressed by the plug-in remedy. This common problem statement is formulated through the evaluation of the site conditions addressed in precedent decision documents (e.g., previous RODs) and based on the existing knowledge of the candidate operable units.
Uncertainties are inherent and will always need to be managed.	By establishing a comprehensive decision making framework, this ROD identifies the type and level of information needed to achieve remedial decision. This focuses site specific evaluations and minimizes the uncertainty associated with remedy selection. Further, this ROD provides the rationale for the specific remedy application based on the comparison of site specific characteristics to key decision-making criteria.
Early identification of likely response actions is possible, prudent, and necessary.	By considering previous decisions on similar waste sites, this plug-in approach capitalizes on site precedents to focus directly on a preferred response action. Additionally, by defining decision criteria for applying given remedial technologies, this ROD establishes the range of conditions for which the response action will be effective at future sites, if identified.

Table 2. CERCLA Requirements and how they re met in the Plug-in ROD

CERCLA Requirements	Plug-in ROD Compliance
SCOPING	
"In implementing this (scoping) section, the lead agency should consider the program goal, program management principles, and expectations contained in this rule. The investigative and analytical studies should be tailored to site circumstances so that the scope and detail of the analysis is appropriate to the complexity of site problems being addresses. During scoping, the lead and support agencies shall confer to identify the optimal set and sequence of actions necessary to address site problems..." [40 CFR 300.430(b)	The plug-in approach allows the program goal of remediating operable units that pose risk to human health and the environment as quickly and cost-effectively as possible to be met. Duplicative documentation is eliminated, data collection meets well-defined objectives, and the start of actual remediation is begun considerably earlier in the remediation process.
"Site management planning is a dynamic, ongoing, and informal strategic planning effort that generally starts as soon as sites are proposed for inclusion on the NPL and continues through the remedial design and remedial action phases, to selection from the NPL." [55 FR 8706]	The use of the plug-in approach allows remediation to begin approximately two years earlier than the normal RCRA/CERCLA process allows. In addition, cost savings are realized by the elimination of numerous duplicative standard documents for these similar units.
NEED FOR ACTION	
"The purpose of the remedial investigation (RI) is to collect data necessary to adequately characterize the site for the purpose of developing and evaluating effective remedial alternatives..." [40 CFR 300.430(d)(1)]	The plug-in approach has a bias toward treatment. The approach allows data collection sufficient to show that there is a need for treatment of the contaminated soils.
REMEDY IDENTIFICATION	
"The primary objective of the feasibility study (FS) is to ensure that appropriate remedial alternatives are developed and evaluated such that relevant information concerning the remedial action options can be presented to a decision-maker and an appropriate remedy selected." [40 CFR 300.430(e)(1)]	Potential remedies have been investigated in the LAOCB and OFASB RODs and in the Alternative Screening Report Radioactive Soils/Debris Consolidation Facility/Off Unit Disposal report. All have indicated that in situ stabilization with a low permeability soil cover system is the preferred remedy for radiologically contaminated waste units.
REMEDY SELECTION	
"Remedies selected shall reflect the scope and purpose of the actions being undertaken and how the action relates to long-term, comprehensive response at the site." [40 CFR 300.430(f)]	The common remedy will be protective of human health and the environment and provides the most cost-effective treatment available. The action will be a long-term comprehensive response action for the contaminated soils in the source area.
"To support the selection of a remedial action by documenting all facts, analyses of facts, and site-specific policy determinations considered in the course of carrying out activities in this section shall be documented, as appropriate, in a record of decision..." [40 CFR 300.430(f)(5)(i)]	The decision document used to plug-in specific units to this plug-in ROD will contain sufficient data to support the need for treatment as specified in the plug-in ROD. This plug-in ROD indicates the levels of constituents that pose unacceptable risk. The common remedy will be applied to reduce those risks to acceptable levels through treatment.
IMPLEMENTING THE REMEDY	
"The remedial design/remedial action (RD/RA) stage includes the development of the actual design of the selected remedy and implementation of the remedy through construction. A period of operation and maintenance may follow the RA activities." [40 CFR 300.430(a)]	The plug-in approach will allow streamlining in the design process based on the application of the remedy at multiple units. The period of operation and maintenance will be included in the RD/RA.

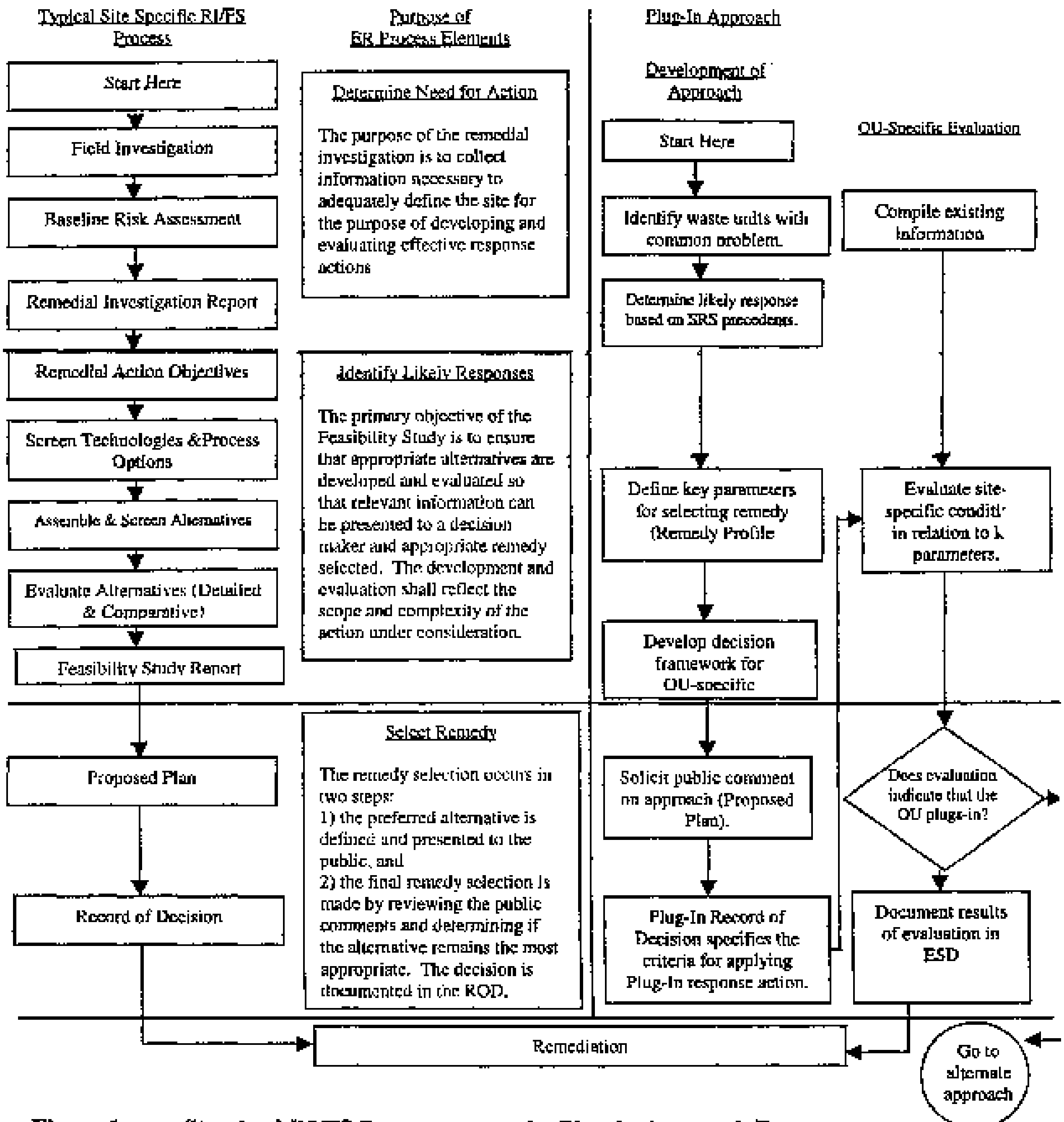


Figure 1. Standard RI/FS Process versus the Plug-in Approach Process

This plug-in ROD will describe the remedy and demonstrate that the preliminary candidate units are likely to meet the conditions that satisfy use of this remedy. To use the plug-in ROD for an OU, a technical evaluation report will be issued followed by an ESD.

The ESD will allow an opportunity for public comment before a decision is made as to whether an OU should use the plug-in ROD.

1.2 Plug-in Approach Components

The plug-in approach can be described by the following components, which will be detailed in the identified sections of the ROD:

Common Unit Characteristics: For the plug-in approach to be beneficial there must be the potential for similar unit problems to be encountered recurrently. Therefore, it must be established that common unit characteristics exist which warrant the identification of a common remedy. Next, a preferred response action is identified for a given set of unit conditions. The preferred response was selected by using the selected remedy and associated decision basis from two completed waste units as precedent for the identified candidate units. The common unit characteristics (e.g., physical conditions and contamination) to be addressed and the decision basis for the selected common remedy will be discussed in Section 5. This section also describes the remedial action objectives.

Common Remedy: The plug-in approach relies on up-front agreement of a preferred response action for a given set of unit conditions. The remedial action (in situ stabilization with a low permeability soil cover system), which has been determined to be effective and preferred for the given set of unit characteristics, is presented in Section 6. This section also describes each aspect of the remedy, how the remedial action objectives will be met, applicable or relevant and appropriate requirements (ARAR), and the estimated cost of the remedy applied to the four units.

Plug-in Decision Framework: Because this ROD will be employed for at least four OU-specific decisions, it is necessary to establish the methodology for evaluating individual units. A decision-making framework is developed in Section 7 to provide a basis for determining if units plug-in to the common remedy identified in this ROD. Plug-in criteria are established to ensure that the candidate units match the conditions that the plug-in remedy has been designed to meet. By focusing early on the preferred response action and pre-determining the conditions that drive its selection and subsequent design and implementation, existing information and additional characterization needs can be more effectively identified to evaluate unit conditions.

Documentation of the Plug-in Decision: . The method of formally documenting that a unit is to be addressed by the plug-in remedy must be established. This will serve as the basis for future documentation and communication with regulators and the public, who will be given the opportunity to comment on the decision to plug specific units into the ROD. The unit-specific technical evaluation report and ESD are described in Section 7, with a template for the technical evaluation report provided in Appendix B.

1.3 Preliminary Candidate OUs

Listed below are the preliminary candidate OUs for this plug-in ROD, including the reactor seepage basins and separations retention basins. The F-Area and H-Area Retention Basins listed are currently active. Additional OUs may be considered for plugging in to this ROD in the future.

C-Area Reactor Seepage Basins (CRSB) (904-66G, -67G, -68G)

K-Area Reactor Seepage Basin (KRSB) (904-65G)

L-Area Reactor Seepage Basin (LRSB) (904-64G)

P-Area Reactor Seepage Basins (PRSB) (904-61G, -62G, -63G)

Warners Pond (685-23G)

F-Area Retention Basin (281-8F)

H-Area Retention Basins (281-1H, -2H, -8H)

2.0 SITE AND OPERABLE UNIT COMPLIANCE HISTORY

Waste materials handled at SRS are managed under the Resource, Concentration, and Recovery Act (RCRA), a comprehensive law requiring responsible management of hazardous waste. Certain SRS activities have required federal operating or post-closure permits under RCRA. SRS received a hazardous waste permit from SCDHEC, which was most recently renewed on September 5, 1995. Part V of the permit mandates that SRS establish and implement a RCRA Facility Investigation (RFI) program to fulfill the requirements specified in Section 3004(u) of the federal permit. Units that managed hazardous waste after 1980 and had releases to the environment must be addressed under RCRA Corrective Action Programs.

In addition to RCRA compliance, on December 21, 1989, SRS was included on the National Priorities List (NPL). The inclusion created a need to integrate the established RFI program with CERCLA requirements to provide a focused environmental program. In accordance with Section 120 of CERCLA, US DOE has negotiated an FFA (FFA 1993) with US EPA and SCDHEC to coordinate remedial activities at SRS into one comprehensive strategy that fulfills these dual regulatory requirements.

Releases of radioactive contaminants at nonpermited waste units are subject only to CERCLA requirements. The preliminary candidate units did not receive any RCRA hazardous wastes and the contaminated soils do not meet the criteria for characteristic hazardous wastes, thus the candidate units are not subject to the permit requirements. Each of the preliminary candidate OUs presented in Section 1.3 are identified in the SRS FFA and as such must be investigated to determine if the OU contains unacceptable risks and if remedial actions are warranted. Sampling may be conducted for the OUs as part of an approved remedial investigation (RI) work plan or as part of a precharacterization work plan.

By separate Memorandum of Agreement (MOA), the US EPA, the SCDHEC, and the US DOE agreed to implement facility-wide, certain periodic site inspection, certification, and notification procedures set forth in a Land Use Control Assurance Plan (LUCAP), developed pursuant to the US EPA Region IV Land Use Controls (LUC) Policy. These procedures are designed to ensure the maintenance by US DOE-SRS personnel of any site-specific LUCs, set forth in a response action decision document, deemed necessary for future protection of human health and the environment. A fundamental premise underlying execution of that MOA was that through US DOE-SRS's substantial good-faith compliance with the procedures called for in the LUCAP, reasonable assurances would be provided to US EPA and SCDHEC as to the permanency of those remedies, which included the use of specific LUCs

Although the terms and conditions of the LUCAP MOA are not specifically incorporated or made enforceable herein by reference, it is understood and agreed upon by US DOE-SRS, US EPA, and SCDHEC that the contemplated permanence of the remedy reflected herein is in part dependent upon US DOE's substantial good-faith compliance with the specific LUC maintenance commitments reflected therein. Should such compliance not occur or should the MOA be terminated, it is understood that the protectiveness of the remedy concurred in may be reconsidered and that additional measures may need to be taken to adequately ensure necessary future protection of human health and the environment.

3.0 SCOPE AND ROLE OF THE PLUG-IN ROD WITHIN THE SITE STRATEGY

OUs at SRS generally consist of both source unit (contaminated soils and/or pipelines) and potentially impacted media such as surface water, sediment, and groundwater. The source unit at these waste units accounts for a significant portion of the current risk to human health and the environment at the OU and may present a potential long-term threat to groundwater. Therefore, expedient and effective source unit control is key to this plug-in OU strategy and the overall site cleanup strategy. The preliminary candidate source units include the high-risk radioactively contaminated open reactor seepage basins. Groundwater and other potentially impacted media will be addressed under separate decisions.

A typical radioactive seepage basin area of contamination (AOC) may consist of several basins, associated pipelines, soil contaminated by leaking pipelines, and possibly adjacent surficial contamination. Figure 2 is a schematic diagram that shows the relationship between the reactor areas, the OUs within those areas, and the source unit AOC for a candidate OU. The remedy will address contamination in all these areas and identify opportunities to consolidate contaminated soils, thus minimizing the footprint of contamination and maximizing the efficiency of the remedial action.

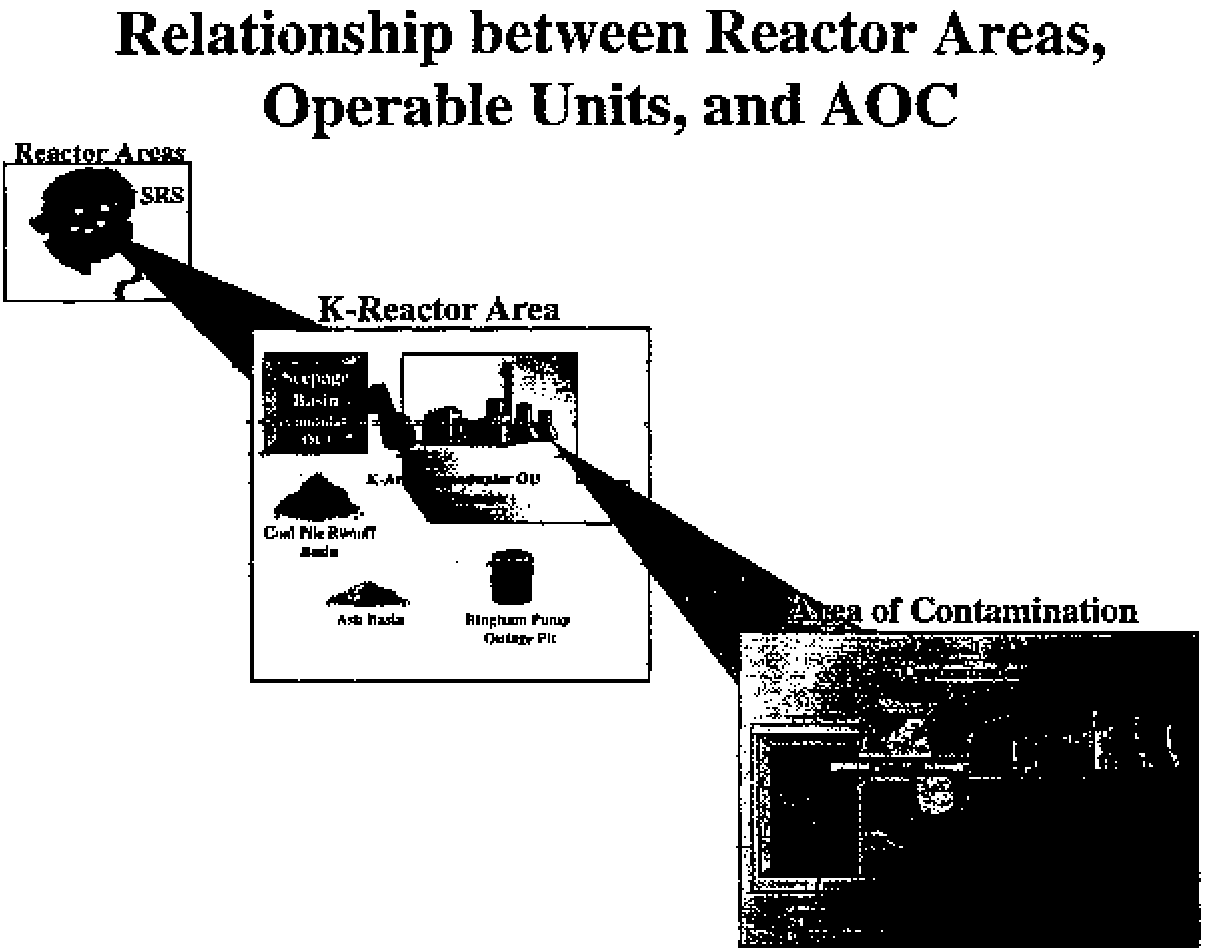


Figure 2. **Relationship between Reactor Areas, Ous, and AOCs**

The remedy, in situ stabilization with a low permeability soil cover system, is applicable to those radioactively contaminated waste units located within areas designated as current industrial use with buffer areas and are adjacent to existing nuclear facilities. The units will be maintained under institutional control for the long term. A Land Use Control Implementation Plan (LUCIP) for each OU will specify the area of institutional control for that specific unit. The remedy selected in this ROD is designed to significantly reduce the risk from the source unit to future workers and potential ecological receptors. It is also designed to prevent migration of soil contaminants to the groundwater.

Candidate OU's will be evaluated to verify that they plug into the plug-in ROD in accordance with their schedules as defined in the FFA. For those OUs where the plug-in ROD does not address all media (e.g., groundwater, surface water, etc.), the plug-in ROD is an interim ROD that provides a final remedy for the source unit and does not impact the ability to remediate all additional media. A final unit-specific ROD will be required for these OUs to complete remedial decision making, according to a schedule agreed upon by US DOE, US EPA, and SCDHEC through the FFA. The administrative status of each action will be clearly defined in the ESD prepared for each unit.

4.0 SAVANNAH RIVER SITE CHARACTERISTICS

SRS occupies approximately 777 square (km) (310 mi^2) of land adjacent to the Savannah River, principally in Aiken and Barnwell counties of South Carolina. SRS is a secured United States Government facility located approximately 40 km (25 mi) southeast of Augusta, Georgia, and 32 km (20 mi) south of Aiken, South Carolina. Figure 3 shows the locations of the four preliminary candidate units at SRS.

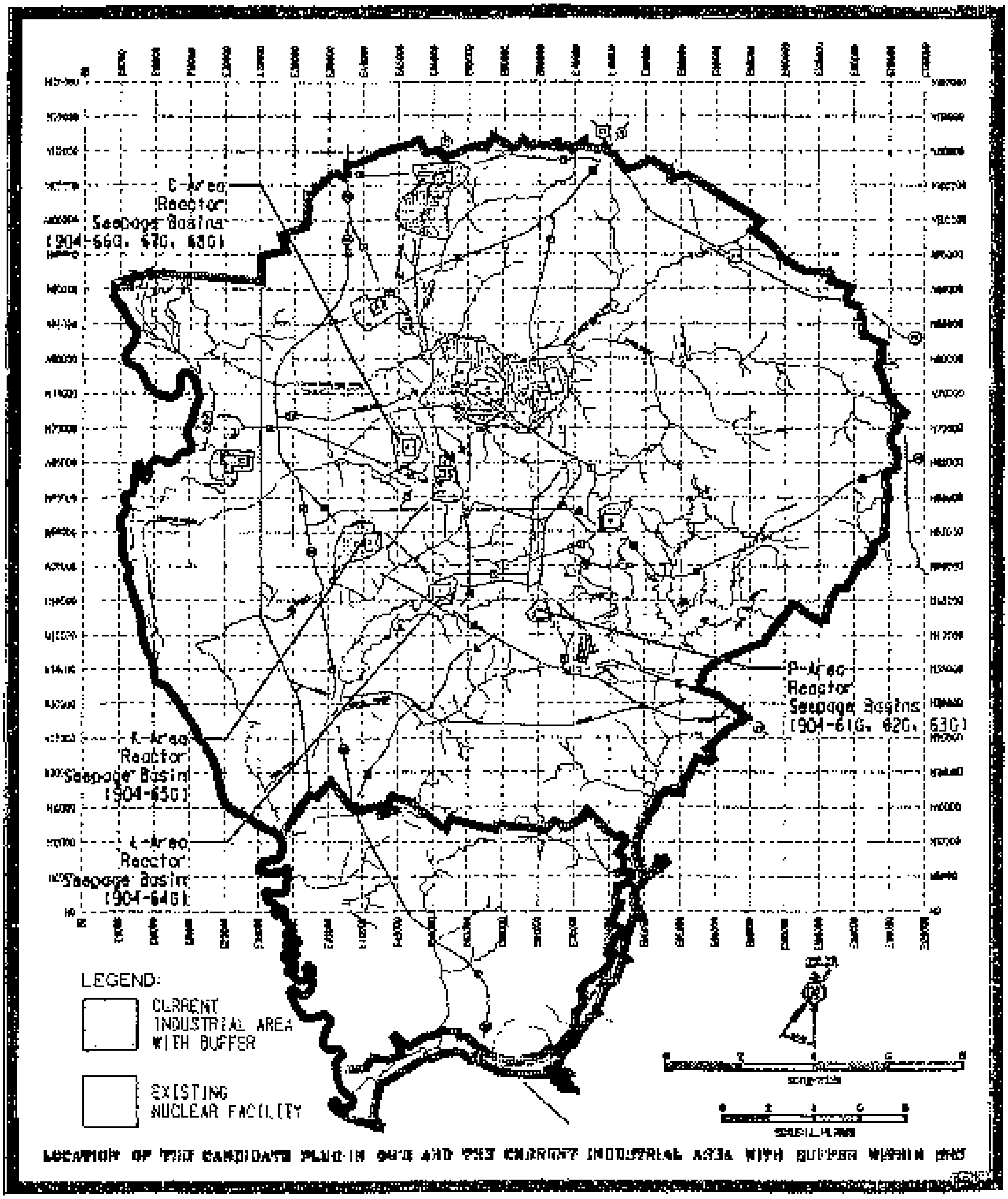


Figure 3. Map of SRS Showing the Location of the Candidate Plug-in OUs, Industrial Use Areas (with Buffer), and the Current Nuclear Facilities

SRS has historically produced tritium, plutonium, and other special nuclear materials for national defense. SRS has also provided nuclear materials for the space program and for medical, industrial, and research efforts. The nuclear material production processes required to support these efforts have resulted in chemical and radioactive wastes. These wastes have been treated, stored, and in some cases, disposed at SRS. This ROD addresses radioactively contaminated source units (soils and pipelines) impacted by the discharge of liquid process wastes contaminated with radionuclides. These past waste handling practices were consistently implemented at the reactor areas.

4.1 Demographics and Land Use

According to 1990 census data (Rand McNally 1992), the average population densities (people per square mile) for the surrounding South Carolina counties are 111 for Aiken County, 36 for Barnwell County, and 28 for Allendale County. The average population densities for the surrounding Georgia counties are 228 for Columbia County, 524 for Richmond County, 25 for Burke County, and 21 for Screven County. The 1990 population within an 80.5 km (50 mi) radius of SRS was 635,000 people. The estimated population for the area in the year 2000 is projected to be 852,000 (Rand McNally 1992).

Less than five percent of the land in the area surrounding SRS is devoted to urban and other development uses (WSRC 1993). Most of the urbanized development in the area has occurred in and around the cities of Augusta, Georgia, and Aiken, South Carolina. By the year 2000, a projected two percent increase in the development of urban land surrounding SRS is expected. Agriculture accounts for about 24 percent of total land use; forests, wetlands, water bodies, and unclassified land, which is predominantly rural, account for about 70 percent.

Less than five percent of the total SRS land area is used by facilities engaged in the production of special nuclear materials. Reservoirs and ponds comprise approximately 13 km^2 (5 mi^2) of SRS. The remaining area, totaling greater than 777 km^2 (300 mi^2) is undeveloped.

The reasonably anticipated future land use for all of the areas that contain the potential plug-in candidate OUs considered in this ROD is industrial. These areas are located near nuclear industrial facilities (WSRC 1995) and are not expected to be released for unrestricted (residential) future land use due to anticipated future nuclear industrial missions at SRS and the significant costs that would be incurred to reduce risks to levels acceptable for unrestricted (residential) use. Figures 4 through 7 show the location of each of the candidate units per Citizens Advisory Board Recommendation #2 and as agreed upon in the FFA Implementation Plan (WSRC 1996a). They are within areas designated as current industrial (with buffer), and are located adjacent to existing nuclear industrial facilities. These areas were selected to remain as industrial areas in US DOE’s future use project report (US DOE 1996a) and are within areas that the Citizens Advisory Board has recommended be retained as industrial future land use areas. Since these areas are designated as industrial, a future industrial worker is assumed as the future human receptor because of the conservative exposure assumptions as compared to a recreational user.

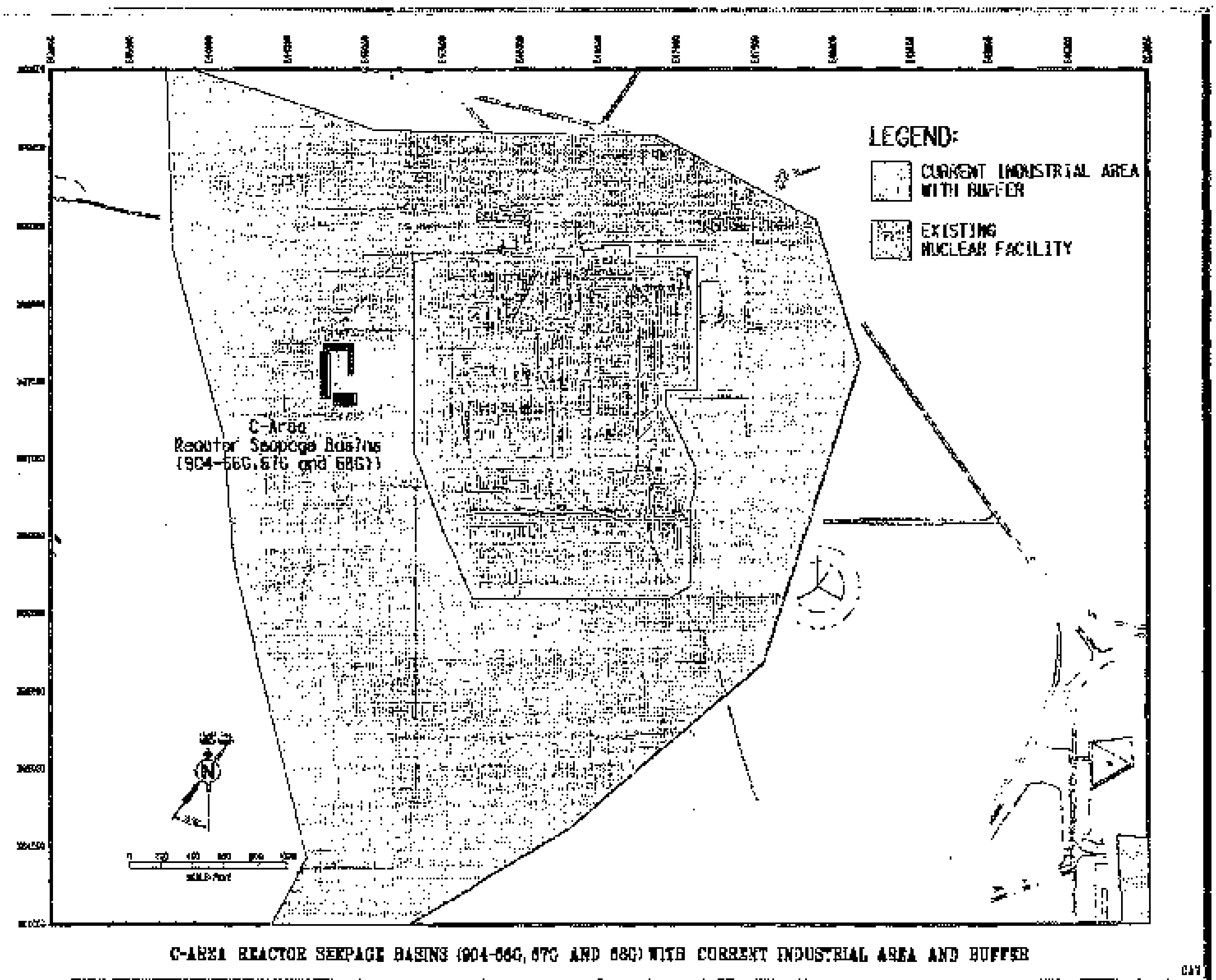


Figure 4. **C-Aria Reactor Seepage Basins (904-66G, -67G, -68G)**

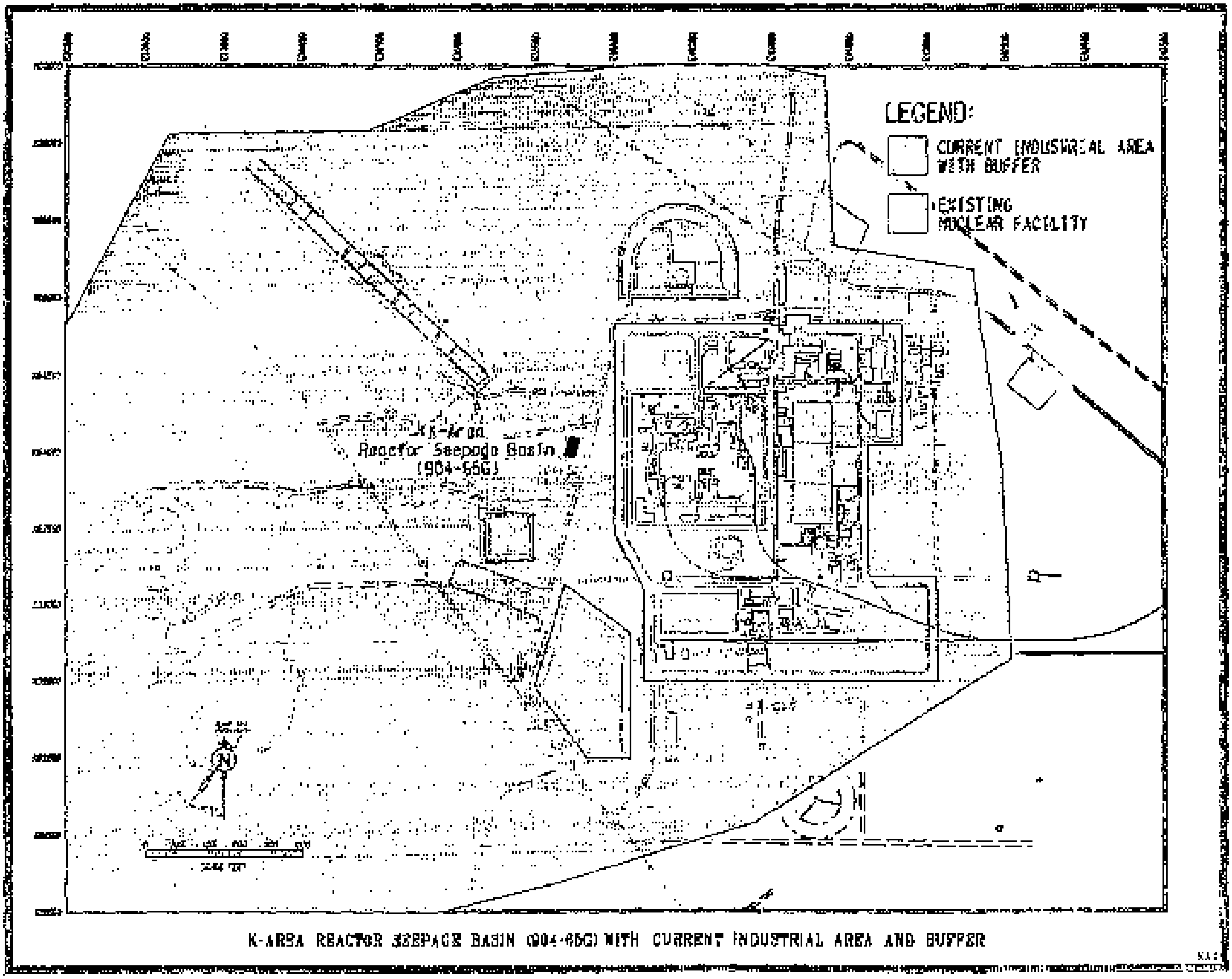


Figure 5. K-Area Reactor Seepage Basin (904-64G)

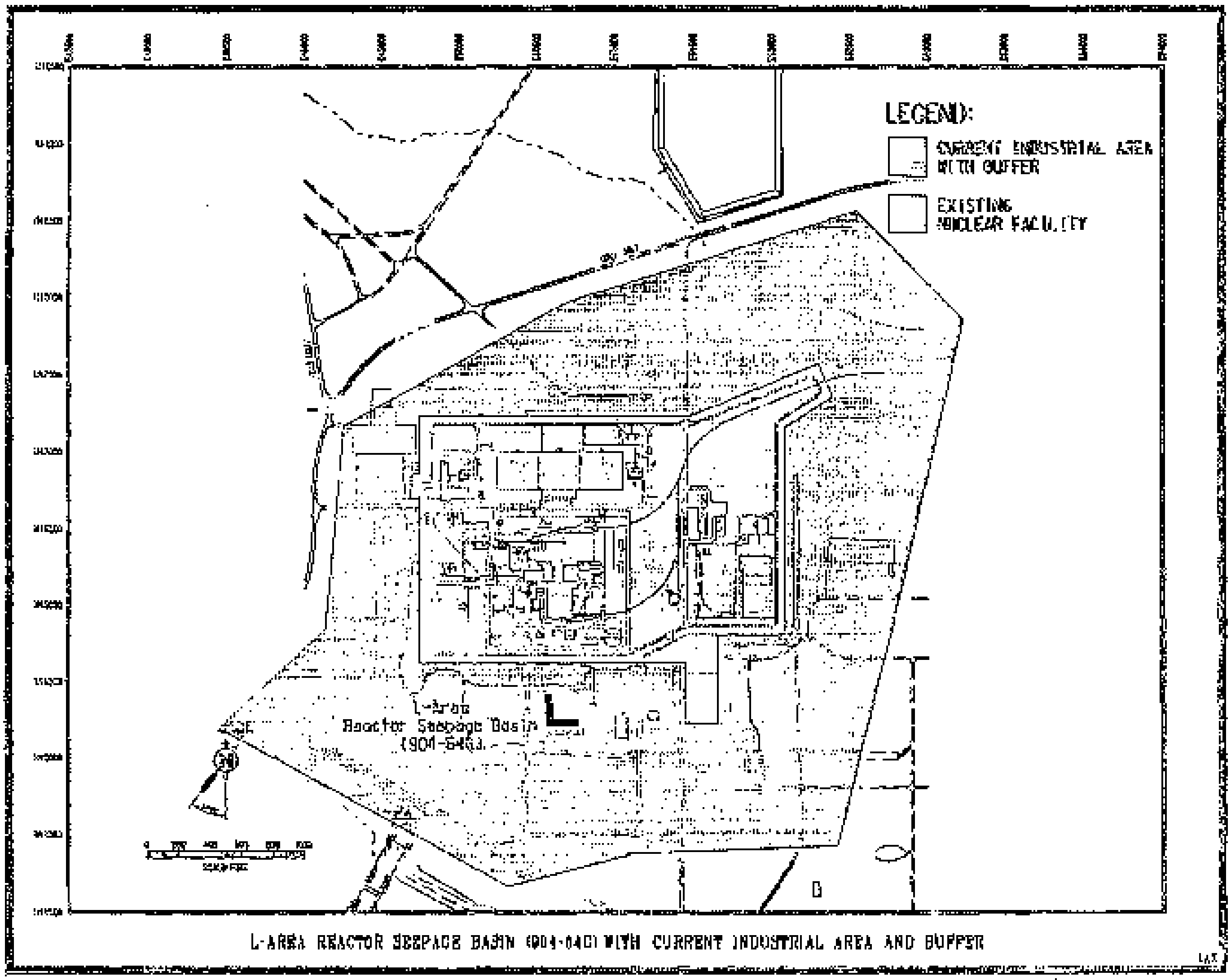


Figure 6. L-Area Reactor Seepage Basin (904-64G)

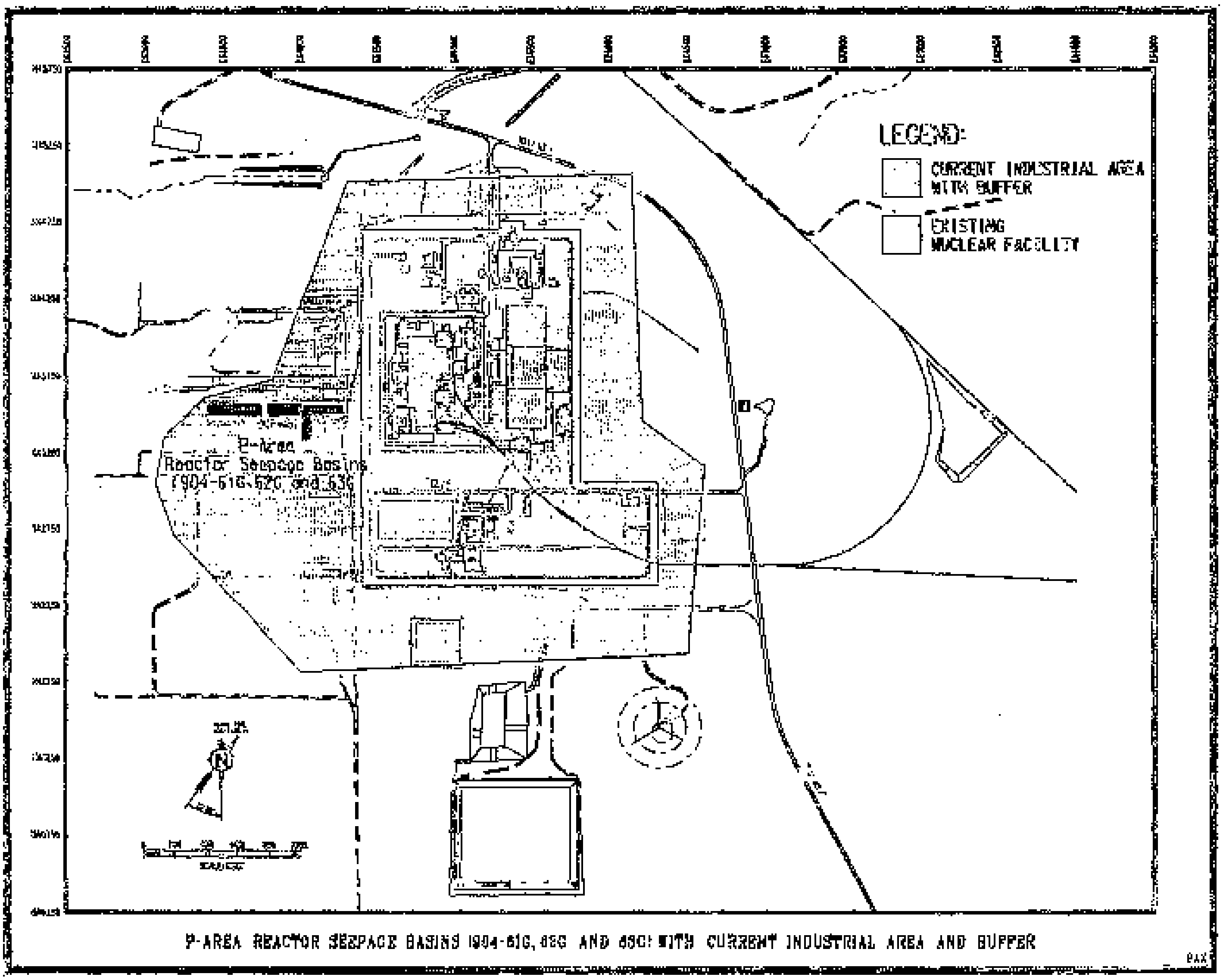


Figure 7. P-Area Reactor Seepage Basin (904-61G, -62G, -63G)

4.2 Ecology

Areas at SRS not used for production and related activities (more than 400 km^2, 156 mi^2) have remained virtually untouched for several decades, except for logging. The following provides an overview of the vegetation and wildlife existing at SRS.

Most of SRS is forested with longleaf and loblolly pines and sweet gum, maple, birch, and various oak and hickory hardwood trees. Major plant communities include cypress-gum and lowland hardwood swamps, sandhills, and old agricultural fields as well as aquatic and semi- aquatic areas. These habitats range from very sandy, dry hilltops to continually flooded swamps.

Some areas of SRS provide refuge for endangered and threatened species, including the red-cockaded woodpecker, the American alligator, the bald eagle, the wood stork, and the smooth purple coneflower. SRS is home to more than 100 species of reptiles and amphibians, including turtles, alligators, lizards, snakes, frogs, and salamanders; and home to over 200 species of birds. SRS is also populated by more than 50 species of mammals, including several thousand white-tailed deer, feral hogs, beavers, rabbits, foxes, raccoons, bobcats, river otters, and opossums.

The typical sizes of most of the radiologically contaminated units (e.g., seepage basins) are up to a few acres. They are generally located in open (non-forested) areas. Previous ecological assessments of similar units (WSRC 1997b) have concluded that the habitat is low in diversity and productivity. Based on the type of units this ROD addresses, small mammals are the most likely target receptors.

4.3 Meteorology

The climate of the area is temperate and characterized by mild winters and warm, humid summers. The annual average temperature at SRS is 17EC (64.3EF). Monthly mean temperatures are coolest in January 7EC (45.3EF) and warmest in July 27EC (83.3EF). Temperatures below freezing occur approximately 58 days per year. The average annual precipitation at SRS is 122 cm (48 in.), distributed fairly evenly throughout the year (USDA 1990). The highest calculated 24-hour precipitation event with a recurrence interval of 100 years is 20.8 cm (8.2 in) (US DOE 1990). Wind speed and direction in the area are variable, depending on the time of year.

4.4 Soils

The soils at SRS are generally characterized as gently sloping to moderately steep, with those on uplands and bottom land nearly level. Most of the soils are well to excessively drained, with a sandy surface layer underlain by a loamy subsoil. Exceptions are those soils in floodplains and wetlands, which are generally poorly drained (USDA 1990).

The soil types of the reactors areas, which include the four candidate units specified in this ROD, are predominantly of the Fuquay-Blanton-Dothan Association. This association consists of nearly level to sloping, well-drained soils on all of the broad upland ridges in the area (USDA 1990). Nearly all the soil in the vicinity of the waste units is Udorthent, soil that has had its profile disturbed by construction activities. These well-drained soils may be firm (e.g., soil at the bottom of an excavation) or friable (excavation spoils), with low organic content, low water capacity, and strongly too extremely acidic (USDA 1990). These soils typically exhibit significant natural variation in their metals content, as demonstrated by the results from hundreds of background soil samples (WSRC 1990; US DOE 1996b).

4.5 Geology

SRS is located on the Atlantic Coastal Plain and is underlain by a seaward-thickening wedge of unconsolidated and semi-consolidated marine and fluvial sediments. These sediments, ranging in thickness at SRS from 152 to 457 m (500 to 1500 ft), are composed of stratified sands, clays, limestone, and gravels that dip gently seaward at about 71 m/km (35 ft/mile). The sediments range in age from Late Cretaceous to Holocene. Igneous and metamorphic rocks of Precambrian to late Paleozoic age and Triassic age sediments underlie these sediments. The three uppermost units are the Orangeburg Group, which consists of the Congaree, Warley Hill, and Santee Limestone Formation; the Barnwell Group, which consists of the Clinchfield, Dry Branch, and Tobacco Road Sand; and the Upland Unit.

The predominant geologic unit at the surface in the reactor areas is the Barnwell Group. The Clinchfield Formation consists of quartz sand, glauconitic, bimoldic limestone, and clay (Aadland et al 1995). The Dry Branch Formation is divided into the Irwinton Sand Member, the Twiggs Clay Member, and the Griffins Landing Member (Fallaw and Price 1995). The Griffins Landing Member, which overlies the Clinchfield Formation, is composed of variably indurated micrite, calcareous sand and clay and thins from about 15 m (50 ft) at the SRS southeast boundary where it pinches out near the center of SRS. Tan clays overlie and separate the Griffiths Landing Member from the Irwinton Sand Member. Lithologically similar tan clay is found at about this stratigraphic level in the Dry Branch Formation in Georgia and is referred to as the Twiggs Clay Member. The Irwinton Sand Member contains quartz sand with interbedded clay and pebbly layers. Its thickness is variable, ranging from 12 m (40 ft) northwest to 21 m (70 ft) southwest (Aadland et al 1995). The Tobacco Road Formation, which overlies the Irwinton Sand Member of the Dry Branch Formation, consists of multicolored fine to coarse, clayey quartz sand with interbedded pebble layers and clay laminae (Aadland et al. 1995).

Overlying the Tobacco Road Formation is a unit commonly referred to as the “Upland unit”, which consists of poorly sorted, silty, clayey sand, pebbly sand, and conglomerate. This unit caps many of the hills at higher elevations throughout SRS (Aadland et al. 1995). Preliminary findings of the Upland unit study (Colquhoun et al. 1994) suggest that the Upland unit, Tobacco Road Formation, and Dry Branch Formation are similar in texture and lithologic composition.

4.6 Hydrogeology and Hydrology

The Late Cretaceous and Tertiary age sediments that make up the Southeastern Coastal Plain hydrogeologic province in the SRS region have been grouped into three aquifer systems divided by two confining systems (Aadland et al 1995). In descending order, the aquifer systems in the study area include the Floridan, Dublin, and Midville aquifer systems. The Myers Branch and Allendale confining systems separate them in descending order. The Dublin and Midville systems merge in the central portion of the site, and are locally separated by the McQueen Branch confining unit. Locally individual aquifer and confining units are delineated within each of the aquifer systems. The Floridan aquifer system consists of two aquifers in the SRS area, the Upper Three Runs aquifer and the underlying Gordon aquifer. The Gordon confining unit separates these aquifers. The following discussion will focus on the Upper Three Runs aquifer unit as it is the uppermost aquifer unit associated with the reactor areas and, therefore, first to be impacted by the source units addressed in this ROD.

The Upper Three Runs aquifer may include sands and clayey sands of the Santee/Tinker Formation, and sediments of the Dry Branch Formation, Tobacco Road Formation, and where present, Upland unit. The sediments become more calcareous moving southward across SRS.

The location and depth of creek incisement in the area (Aadland et al. 1995) control the hydraulic head distribution of the aquifer. This incisement has divided the interstream areas of the water table aquifer into “groundwater islands” that behave as independent hydrogeologic subsets of the water table aquifer with unique recharge and discharge areas. The stream acts as the groundwater discharge boundary for the interstrearn area. The head distribution pattern in these areas tends to follow topography, with higher heads at the higher elevations between streams with gradually declining heads toward the bounding streams.

The porosity and permeability of the Upper Three Runs aquifer are variable, generally increasing toward the south with increasing calcareous content (Aadland et al 1995). The aquifer typically yields low quantities of water based on the presence of interstitial silts and clays. This aquifer has been further separated into upper and lower aquifer zones by the tan clay-confining zone. The upper aquifer zone consists of the saturated strata in the Dry Branch Formation and Tobacco Road Formation and generally exhibits a downward hydraulic potential across the tan clay confining zone, which separates the upper and lower aquifer zones and impedes the vertical movement of water.

Recharge to the Upper Three Runs aquifer occurs by infiltration from the surface. In the upper aquifer zone, part of the groundwater moves laterally toward the bounding streams and part moves vertically downward across the tan clay. Most of the groundwater recharging the lower aquifer zone also moves laterally toward the bounding streams.

All of SRS is drained by the Savannah River, which forms the southwestern boundary of SRS and the Georgia-South Carolina border. Major tributaries to the Savannah River that flow southwestward across SRS are Upper Three Runs Creek, Tinker Creek, Four Mile Creek, Pen Branch, Steel Creek, and Lower Three Runs Creek. P and L Areas drain into Steel Creek. K Area drains into Pen Branch, and C Area drains into Fourmile Branch.

5.0 JUSTIFICATION OF THE COMMON REMEDY

The first part of this section will summarize the previous evaluations of radioactive disposal basins and the key aspects of the common conceptual site model (CSM). The second part of this section will discuss the known features of the candidate units, demonstrating that they share the same key aspects of the common CSM, and develop remedial action objectives. (RAOs) for the common remedy.

5.1 Rationale

Two radioactive disposal basins at SRS, the Old F-Area Seepage Basin (OFASB) and L-Area Oil and Chemical Basin (LAOCB) have undergone complete evaluations under the FFA environmental restoration program. Based on the detailed analysis completed for these two units, they share similar CSMs with the following key aspects:

- receipt of radioactively contaminated waste water,
- presence of elevated levels of radionuclides as primary soil contaminants at levels that can be classified as principal threat source material,
- location in an industrial area (with buffer) adjacent to a current nuclear facility,
- unacceptable risks to future workers in their current state,
- contaminated soils not in direct contact with surface water or groundwater, and
- potentially contaminated associated pipelines.

The same remedial action decision (in situ stabilization with a low permeability soil cover) was reached at both units (WSRC 1997b, 1997c). Based on these decisions, this remedy should be applicable to other radioactively contaminated units with similar CSMs. The case for a common remedy was further supported by an alternatives study of the radioactively contaminated operable units presented in the *Alternative Screening Report, Radioactive Soils/Debris Consolidation Facility* (WSRC 1997a).

5.2 Previous Unit Evaluations

Several questions can be derived from the previous evaluations performed on the LAOCB and OFASB that are key to showing that a common CSM exists.

- Are the operable units that were previously evaluated similar in the nature and extent of the contamination?
- Were the RAOs similar for the units?
- Was a comparable analysis of alternatives performed for the units and did the independent analysis reach the same conclusions?

5.2.1 Nature and Extent of Contamination

The following paragraphs briefly describe the history, physical description, and nature and extent of contamination for the OFASB and the LAOCB.

Old F-Area Seepage Basin (OFASB)

The OFASB is located in a current industrial use area (with buffer) adjacent to a current nuclear facility in the central portion of SRS, about 9.6 km (6 mi) from the nearest SRS boundary, which is the Savannah River (see Figure 3). It is located on the top of a gentle slope at an elevation of 87 m (285 ft) above mean sea level (msl). The basin is an open unlined basin measuring about 61 to 91 m (200 by 300 ft). The bottom of the basin is about 3 m (10 ft) below grade. The unit includes one effluent ditch line adjacent to the basin and 244 m (800 ft) of pipeline at an average depth of 3 m (9 to 10 ft) below the ground. The pipeline once gravity-fed the basin. The OFASB was used in 1955 and intermittently until 1969 for the disposal of wastewater from evaporators, nonreactor cooling water from F&H Areas, and other chemicals such as spent nitric acid solutions. Between 9 and 14 million gallons were discharged to the basin, which served as an unlined seepage basin for reducing radioactive substance concentrations and other nonradioactive chemicals. Approximately 1 to 8 Ci of radionuclides were released to the basin (see Table 3). The water table aquifer (Upper Three Runs aquifer zone) is about 23 m (75 ft) below the ground surface and discharges to Upper Three Runs Creek, which is the nearest surface water feature (over 762 m, 2500 ft from the unit). Standing water is present in the basin during the wet seasons.

The primary contamination associated with the OFASB consists of radionuclides in the first 0.6 m (2 ft) of soil, although contaminants were found up to 7.6 m (25 ft) below the basin bottom. Surficial soil contamination also occurs in the effluent ditch line. Cesium-137 and mercury are the major soil contaminants. The maximum cesium-137 concentration is 1,345 pCi/g at 0 to 0.3 m (1 ft) below the basin bottom.

Table 3. Estimated Inventory of Radioisotopes in Potential Plug-in ROD Waste Units

Isotope	LAOCB	OFASB	CRSBs	KRSB	LRSB	PRSBs
Am-241	1.78E-03	5.69E-03	2.49E-03	9.47E-04	6.39E-03	6.39E-03
C-14	1.70E-05	5.44E-05	2.38E-05	3.49E-03	6.10E-05	6.10E-05
Cs-137	7.50E-01	2.00E-00	1.15E+00	8.42E-01	2.94E+00	2.94E+00
I-129	1.47E-07	7.55E-02	2.06E-07	1.77E-07	5.28E-07	5.28E-07
Pu-239	1.12E-02	3.52E-01	1.57E-02	1.35E-02	4.04E-02	4.04E-02
Sr-90	6.58E-02	2.41E-02	1.01E-01	6.67E-02	2.58E-01	2.58E-01
Tc-99	1.79E-04	5.73E-04	2.51E-04	2.15E-04	6.43E-04	6.43E-04
U-238	5.68E-04	5.33E-01	7.95E-04	4.17E-03	2.04E-03	2.04E-03
H-3	<2.70E+02	NA	5.60E+04	NA	NA	NA

Note: All values are in curies.
Cobalt-60, which was present at significant activities in most waste streams, has no inventory information associated with it.
NA=Not Available
CRSBs=C-Area Reactor Seepage Basins
KRSB=K-Area Reactor Seepage Basin
LRSB=L-Area Reactor Seepage Basin
PRSBs=P-Area Reactor Seepage Basins
LAOCB=L-Area Oil and Chemical Basin
OFASB=Old F-Area Seepage Basin

The risks posed due to exposure to the basin soil are unacceptable for the future hypothetical worker. A carcinogenic risk of 9.4 x 10^{-3} was calculated for exposure to basin soils from external radiation. This pathway accounts for almost 99% of the exposure risks (as compared to inhalation and ingestion). The risk drivers are primarily cesium-137 (95%)and cobalt-60 (2.5%). Based on the significant risk (greater than 1 x 10^{-3}) that these soils would pose if exposure was to occur, these soils can be considered principal threat source materials (PTSMs) (US EPA 1991a). High levels of long-lived radionuclides were not found in the soils. Depth to groundwater is about 70 ft below ground surface (bgs). Iodine-129, nitrate, strontium-90, tritium, radium, and uranium were found in groundwater at concentrations that exceeded maximum contaminant levels (MCLs) or proposed MCLs (WSRC 1997c).

L-Area Oil and Chemical Basin (LAOCB)

The LAOCB is located in a current industrial use area (with buffer) adjacent to a current nuclear facility in the south central portion of SRS about 11. km (7 mi) from the Savannah River (see Figure 3). The basin is an open, unlined basin measuring 55 m by 33 m (182 ft by 108 ft) with an average depth of 3.6 m (12 ft) below grade. The basin received wastewater via gravity flow from a 6-in diameter steel pipeline extending 137 m (450 ft) from the L-Area Hot Shop as well as wastes from other reactors transported in drums and tank trucks. A 2-in steel pipeline also runs from the Hot Shop to the basin. The basin received waste from the Hot Shop from 1961 to 1979. The wastewater (largely decontamination fluids) contained radionuclides, detergents, and spent solvents. Approximately 2.2 Ci of alpha emitters and 270 Ci of nonvolatile beta emitters were received by the basin (see Table 3). The groundwater table is about 6 to 7.6 m (20 to 25 ft) below the surface and discharges to L-lake, which is the nearest surface water body and is located about 381 m (1,250 ft) south of the basin. Standing water is present in the basin at most times.

The primary contamination associated with the LAOCB consists of radionuclides and metals in the shallow soils 0 to 0.6 m (0 to 2 ft) in the basin. Standing water in the basin also contained elevated levels of radionuclides. Vegetative sampling indicated elevated levels of cesium-137 and cobalt-60. The basin bottom contains about 0.15 m (6 in) of sludge above the sediments. Twenty-four radionuclides were detected in this layer, including long-lived radionuclides such as plutonium-238, plutonium-239, and uranium-238. Radioisotopes present at activities over 1,000 pCi/g included cesium-137, cobalt-60, strontium-90, uranium-238, and tritium (as hydroxides). The concentration in the basin decreases rapidly with depth because of the nature of the sediments (clay hardpan) at the basin bottom. No man-made contamination was found outside of the security fence around the basin. The risks posed by exposure to the basin soils are unacceptable to the hypothetical future worker. This thin zone of highly contaminated sediments and soils can be considered PTSM. A radionuclide-related carcinogenic risk of 2.4×10^{-2} from external exposure was calculated; cobalt-60 (84%) and cesium-137 (11%) were the risk drivers. (WSRC 1997b).

<u>Similarities in Nature and Extent of Contamination</u>

The unit characterizations indicated that the nature and extent of contamination for both units are similar and the CSMs for these two units are almost identical. A generic CSM that describes both OFASB and LAOCB is presented in Figure 8.

5.2.2 Previous Units Remedial Action Objectives (RAOs)

RAOs consist of medium-specific or OU-specific goals for protecting human health and the environment. The RAOs for both source units were similar and included the prevention or reduction of risks to human health and the environment. The RAOs summarized below were to prevent

- external exposure to radiological constituents,
- inhalation of radiological constituents,
- ingestion of soil or produce with radiological constituents, and
- leaching and migration of constituents of concern (COCs) to the groundwater.

5.2.3 Previous Units Evaluation of Alternatives

The following sections discuss the alternatives evaluated and selected for the OFASB and the LAOCB, (WSRC 1997b, 1997c). The alternatives evaluated in the *Alternative Screening Report, Radioactive Soils/Debris Consolidation Facility* (WSRC 1997a) are also discussed.

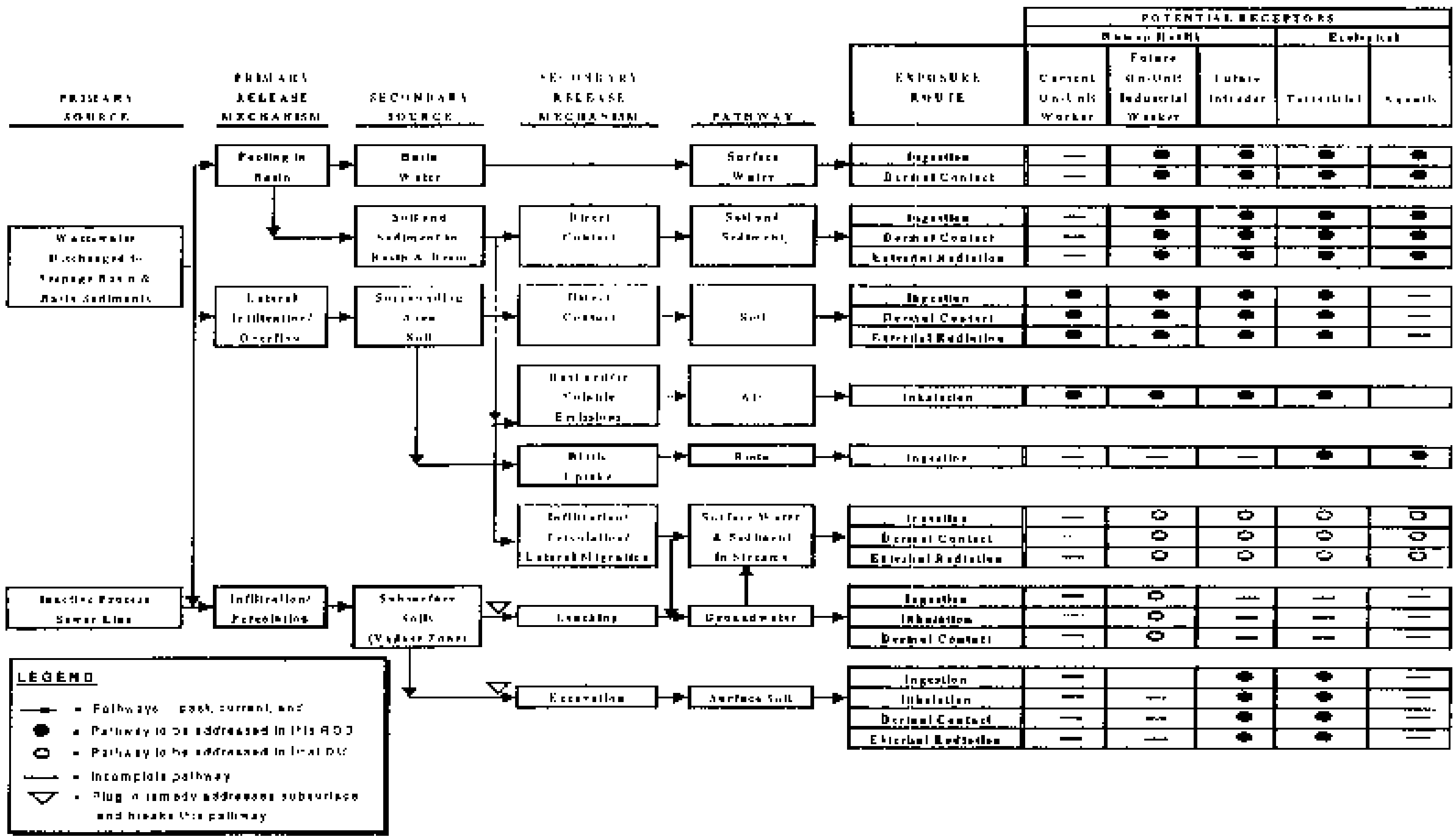


Figure 8. Conceptual Site Model for a Typical Candidate Radioactive Basin

The OFASB (WSRC 1997c) project evaluated the following remedial alternatives:

1. No Action

2. Cap the Basin and Vegetation

3. Consolidate Ditch Line Soils, In Situ Grout Soils to 0.6 m (2 ft), and Incinerate Vegetation at Consolidated Incinerator Facility or Dispose of Vegetation Off Unit

4. Ex Situ Grout Soils to 0.6 m (2 ft) and Incinerate Vegetation at Consolidated Incinerator Facility or Dispose of Vegetation Off Unit

5. Dispose of 0.6 m (2 ft) of Soils at Envirocare, Incinerate Vegetation at Consolidated Incinerator Facility and Cap

An alternative comparison summary table is provided in Appendix A.

The results of the evaluation of these alternatives indicated that all alternatives except No Action were comparable with respect to overall protectiveness of human health and the environment, compliance with ARARs, and implementability. Alternative 5 provided the greatest long-term protectiveness because the waste is completely removed. Alternatives 3 and 4, which included stabilization (grouting), were determined to be best at reducing toxicity, mobility, or volume through treatment. In situ stabilization and capping (alternatives 2 and 3) provided the greatest short-term protectiveness because contamination is not exhumed, handled, or disposed of off unit, as proposed for alternatives 4 and 5. Alternatives 2 and 3 also provide the most cost-effective solutions. Based on consideration of all of the criteria, Alternative 3, consolidate ditch line soils, in situ grout (stabilize) soils to 0.6 m (2 ft), and incinerate vegetation at the Consolidated Incinerator Facility or dispose of vegetation off-unit, was determined to provide the most cost-effective protection over both the short and long term, as well as reduce the mobility of the contaminants, and was selected as the remedy. This alternative also includes grouting the pipelines at the manholes to limit access.

The following remedial alternatives were evaluated at the LAOCB (WSRC 1997b):

1. No Action
2. Backfill and Cap
3. Backfill, Install Slurry Cut-Off Walls Around the Basin, und Cap
4. In Situ Solidification/Stabilization, Backfill and Cap
5. Ex Situ Stabilize, Backfill and Cap
6. Excavation and Off-Unit Disposal

An alternative comparison summary table is provided in Appendix A.

The results of the evaluation of these alternatives indicated that all alternatives except No Action were comparable with respect to overall protectiveness of human health and the environment, compliance with ARARs, and implementability. The primary discriminators between the alternatives were cost, long-term effectiveness and permanence, and reduction of toxicity, mobility or volume through treatment. Alternative 6 provides the greatest long-term effectiveness due to removal of all the contaminated material. However, Alternatives 5 and 6 were discounted due to excessive cost and short-term risk to workers from potential exposures during excavation. Alternative 4 may provide greater protection from long-term residual on-unit risks than Alternatives 2 or 3, given that a stabilized waste form will be less accessible. Alternatives 3 and 4 were found to reduce mobility of contaminants more permanently than Alternative 2, and Alternative 4 also reduces the mobility of contaminants through stabilization, thus meeting the National Contingency Plan (NCP) preference for treatment. The costs for Alternative 4 were not excessive as compared to Alternative 2 (2.5 times greater), based on the thin layer of soils that need to be stabilized. Alternative 4, in situ stabilization, backfill, and cap, was determined to be most effective at reducing mobility of contaminants through treatment over the long-term; therefore it was selected as the remedy. This remedy includes excavation and disposal of the pipeline into the basin.

At both the OFASB and the LAOCB, in situ stabilization with a low permeability soil cover system was preferable to other potential remedies (e.g., excavation and disposal) based upon an evaluation against the nine CERCLA criteria in the alternative analysis.

The *Alternative Screening Report, Radioactive Soils/Debris Consolidation Facility* (WSRC 1997a) evaluated whether the construction of a soils consolidation facility was warranted for the numerous radiologically contaminated units at SRS. The following alternatives were evaluated and compared for 20 potential operable units:

1. No Action
2. Cap Units
3. In Situ Grout (Stabilize) Contaminated Soils/Debris, Cap Units
4. Excavate Contaminated Soils/Debris, Ex Situ Grout, Replace Treated Soils and Debris, Cap Units
5. Excavate Contaminated Soils/Debris, Dispose at the SRS E-Area Vaults
6. Excavate Contaminated Soils/Debris, Dispose at the Radioactive Soils/Debris Consolidation Facility
7. Excavate Contaminated Soils/Debris, Dispose at the Nevada Test Site

Alternatives 1 and 2 are not protective of human health and the environment. Alternative 2 does not use treatment as part of the remedy. Alternative 4 is less cost effective than Alternative 3. Of the three offsite disposal alternatives, Alternative 6 was considered the best. A comparison of alternatives 3 and 6, the two best alternatives, is provided below. The text expands on the key discriminators of cost and short-term effectiveness.

Both alternatives 3 and 6 are protective of human health and the environment, meet ARARs, treat the contaminated soils to reduce mobility, and would be acceptable to the state. Both are implementable. Alternative 6 offers greater long-term effectiveness than alternative 3, since no wastes would be left at the units. However, the units are located in reactor areas that are not expected to be returned to unrestricted use.

The cost effectiveness of in situ stabilization and capping is shown below. The estimated costs for alternatives 3 and 6 were $56 million and $110 million, respectively. Some of the key assumptions that contributed to the overall cost of the two alternatives involve the volume of soils to be excavated and stabilized, and the long-term O&M costs. The report used very conservative estimates of the amount of soil to be treated, based on the limited characterization data available for each of the operable units. For alternative 3, it was assumed that soil stabilization to depths capturing the extent of contamination or 6 m (20 ft) would be required. However, based on the extent of PTSM present, the volume requiring in situ stabilization is less than assumed by about a factor of five. Likewise, for alternative 6, the volume to be excavated was based on the same assumption, and 75% of the soils excavated were estimated to require stabilization prior to disposal. The assumption regarding the volume of soil to be excavated from the four candidate OUs, if a central disposal facility is to be used, is still valid. The excavation must include soils contaminated with mobile radionuclides (e.g., Sr-90) because no soil cover or cap would be included in the remedy to prevent further migration. The data available to date indicates mobile radionuclides are present at depths similar to those depths used in the SDCF report. However, the assumption that 75% of the excavated material would require stabilization is overly conservative. Based on the need to stabilize PTSM soil, about 20% of the excavated volume would require stabilization. If lower volumes of soil are used to estimate the costs for construction of a consolidation facility, the cost per unit volume of soil will be higher than the costs used in the report. This is because the fixed costs for this facility will be spread over a smaller volume of soil. Finally, although operation and maintenance (O&M) costs for the four OUs would be higher than for one common facility, the difference would be less than a factor of four. For example, much of the required groundwater monitoring will be needed in the vicinity of the seepage basins regardless of whether the soils are removed, as reactor area groundwater in all four areas is contaminated. Considering all these factors, the costs for treating the waste in place are significantly lower than for those involved in relocating the waste to a common facility.

The short-term effectiveness of alternative 3 is better than alternative 6. Disposal of the contaminated soil in a common facility would present a higher worker exposure risk than would in situ stabilization. In situ stabilization would involve very limited contact with the contaminated soil. A layer of clean fill would be placed over the contaminated soil before the stabilization equipment is moved into place. The entire stabilization process would, therefore, be carried out with very little opportunity for the workers to come in direct contact with the contaminated soil. Alternative 6 would require excavation, transport to the facility, ex situ stabilization, disposal in the new facility, and finally decontamination of all of the equipment used. These operations would require greater worker hours than alternative 3; thus the risk of injury is increased for the workers.

In conclusion, except for those waste units located outside of the current industrial use area (with buffer) adjacent to a current nuclear facility, the evaluation determined that the construction of a soils consolidation facility was not appropriate, considering factors of short-term effectiveness, cost, and future land use. The report recommends those waste units located within the current industrial use area (with buffer) and adjacent to a current nuclear facility consider the use of a capping or in situ stabilization/capping response.

Table 4 is a summary level comparison of no action, the Soil/Debris Consolidation Facility, and in situ stabilization with a low permeability soil cover system against the nine CERCLA criteria. This comparison is based on the analyses done in the feasibility studies. for the OFASB and LAOCB and in the *Alternative Screening Report Radioactive Soils/Debris Consolidation Facility (WSRC 1997a).*

5.3 Comparison of Preliminary Candidate OUs to a Common CSM

Other radioactively contaminated units at SRS can be compared against the common CSM to determine if they should be addressed using the same remedy. Based on similar process histories and the available data, CRSB, KRSB, LRSB, and PRSB are some of the preliminary candidate units for the Plug-in ROD that will be described below. Other radioactively contaminated OUs may also be considered as future plug-in candidates as additional information is obtained. The locations of these preliminary candidate units (reactor seepage basins) are shown in Figures 3 through 7.

Table 4. Evaluation Summary of Soil/Debris Consolidation Facility Alternatives 3 and 6 using the Nine CERCLA Criteria

Nine CERCLA Criteria	No Action	Alternative 6 Soil/Debris Consolidation Facility	Alternative 3 In Situ Stabilization with a Low-Permeability Soil Cover System
Overall Protection of Human Health and the Environment	Does not protect human health and the environment.	Protects human health and the environment.	Protects human health and the environment.
Compliance With ARARs	Does not comply with identified ARARs.	Complies with all ARARs.	Complies with all ARARs.
Long-Term Effectiveness	No long-term effectiveness.	Long-term effectiveness provided through land use controls. Footprint of contaminated areas reduced.	Long-term effectiveness provided through land use controls. No footprint reduction; less critical for reactor areas.
Reduction in Toxicity, Mobility, or Volume	Does not reduce toxicity, mobility, or volume.	Reduces accessibility and mobility of contaminated soils through stabilization. Toxicity reduced through natural radioactive decay.	Reduces accessibility and mobility of contaminated soils through stabilization. Toxicity reduced through natural radioactive decay.
Short term Effectiveness.	Not applicable.	Short-term effectiveness poor. Higher worker exposure and injury risk; longer time to implement.	Provides good short-term effectiveness. Minimal worker exposure and lower potential injury risk. Time to implement is shorter.
Implementablity	Fully implementable.	Implementable, although probable excavation of deep soils to meet RGs difficult. A significant number of additional ARARs need to be met for construction and disposal of soil wastes in an engineered facility.	Fully implementable.
Cost	Minimal cost based on five-year ROD reviews.	Cost about 2x alternative 3.	Cost about one-half of alternative 6.
State Acceptance	Will not receive State acceptance.	Would likely receive State acceptance.	Would likely receive State acceptance.
Community Acceptance	Will not receive community acceptance.	Less likely to receive community acceptance.	Will likely receive community acceptance.

The CSMs for these four units are similar. Table 5 summarizes the general features for each of these basins. These open reactor seepage basins all received discharge water from the reactor disassembly basins. The water from the disassembly basins generally contained tritium and other radionuclides such as cesium-137 and strontium-90. Table 3 gives the estimated inventory of radioisotopes for each unit. As shown in this table, cesium-137 and strontium-90 are the predominant radionuclides that were discharged to the basins that would be present as soil contaminants. At CRSB, it is estimated approximately 56,000 Ci of tritium was discharged to the basins (WSRC 1996b).

Table 5. Data for the CRSB, KRSB, LRSB, and PRSB

Operable Unit	Basin	Source of Contamination	Years of Operation	Length (ft)	Width (ft)	Dept h (ft)	Depth to Groundwater (ft)
C-Area Reactor	904-066G	C-Reactor	1957-87	394	36	7	70
Seepage Basins	904-067G	Disassembly	1957-87	296	43	10	70
	904-068G	Basin	1957-87	148	89	13	70
K- Area Reactor Seepage Basin	904-65G	K-Reactor Disassembly Basin	1957-60	135	70	7	56-66
L-Area Reactor Seepage Basin	904-64G	L-Reactor Disassembly basin	1957-88	390	36	7	24
P-Area Reactor	904-61G	P-Reactor	1957-88	386	36	7	40
Seepage Basins	904-62G	Disassembly	1957-88	200	63	8	40
	904-63G	Basin	1957-88	330	60	11	40

Most of the basins were unlined and contaminated water was allowed to seep into the ground. At several of the reactor facilities, the basins were connected in series so that the first basin would fill and any overflow would go to the next until that basin was full. The second basin would then overflow into the third. This type of operation allowed the first few feet of soil in the first basin to become more highly contaminated while the soil in subsequent basins remained less contaminated because

Table 6. Radionuclide Distribution & Risk for CRSB, KRSB, LRSB, and PRSB

Operable Unit	Basin	Sample Depth (ft bbb)	Cs-137 (pCi/g)	Cs-137 (risk)	Sr-90 (pCi/g)	Sr-90 (risk)	Pu (pCi/g)	Pu (risk)	Co-60 (pCi/g)	Co-60 (risk)	Cumulative Risk
CRSB	904-086G	[illegible]	157.00	**1.5E-03**	5.60	9.6E-08	4.66	4.8E-07	9.90	4.4E-04	**1.9E-03**
		[illegible]	145.00	**1.4E-03**	34.50	6.0E-07	10.60	1.0E-06	10.70	4.7E-04	**1.8E-03**
		[illegible]	210.00	**2.0E-03**	136.10	2.4E-06	1.63	1.6E-07	6.72	3.0E-04	**2.3E-03**
		7-10'	1.60	1.5E-05	39.40	6.9E-07	0.04	4.0E-09	0.09	2.5E-06	1.9E-05
		10-13'	1.60	1.3E-05	18.40	3.2E-07	0.09	7.9E-09	0.16	7.0E-06	2.2E-05
		13-16'	1.00	1.8E-05	42	7.3E-07	u	0.0E+00	0.14	6.2E-06	2.5E-05
	904-087G	[illegible]	52.50	5.0E-04	2.40	4.2E-08	1.13	1.1E-07	0.22	9.7E-06	5.1E-04
		[illegible]	113.90	**1.1E-03**	18.50	3.2E-07	0.95	9.4E-08	0.37	1.6E-05	**1.1E-03**
		4-7'	0.38	3.6E-06	24.70	4.3E-07	u	0.0E+00	0.06	2.6E-06	6.7E-06
		7-10'	0.82	7.7E-06	7.20	1.3E-07	0.03	3.0E-09	0.01	4.4E-07	8.3E-06
		10-13'	0.05	4.7E-07	5.10	8.9E-08	u	0.0E+00	u	0.0E+00	5.6E-07
	904-088G	0-1'	9.00	8.5E-05	u	0.0E+00	0.21	2.1E-08	0.01	4.4E-07	8.6E-05
		1-4'	0.20	1.9E-06	u	0.0E+00	u	0.0E+00	0.01	4.4E-07	2.3E-06
		4-5.5'	0.17	1.6E-06	u	0.0E+00	u	0.0E+00	0.01	4.4E-07	2.0E-06
		7-10'	0.01	9.4E-08	0.2	3.5E-09	u	0.0E+00	0.01	4.4E-07	5.4E-07
KRSB	904-65G	[illegible]	1328	**1.3E-02**	111.4	1.9E-06	12.1	1.2E-06	1.73	7.6E-05	**1.3E-02**
		[illegible]	210	**2.0E-03**	36.2	6.3E-07	1.07	1.1E-07	0.25	1.1E-05	**2.0E-03**
		3-5'	24.2	2.3E-04	12.2	2.1E-07	0.48	4.8E-08	0.04	1.8E-06	2.3E-04
		5-7'	23.1	2.2E-04	3.3	5.8E-08	0.18	1.8E-08	0.02	8.8E-07	2.2E-04
		7-9'	46.8	4.4E-04	2.6	4.5E-08	0.65	6.4E-08	0.08	3.5E-06	4.5E-04
		9-11'	97.3	9.2E-04	0.14	2.4E-09	0.16	1.6E-08	0.03	1.3E-06	9.2E-04
		11-13'	15.5	1.5E-04	0.78	1.4E-08	0.41	4.1E-08	u	0.0E+00	1.5E-04
LRSB	904-64G		no data		no data						
PRSB	904-61G	[illegible]	115	**1.1E-03**	44	7.7E-07	na		u	0.0E+00	**1.1E-03**
		[illegible]	49.8	4.7E-04	109	1.9E-06	na		u	0.0E+00	4.7E-04
		[illegible]	33.4	3.2E-04	na		na		28.5	**1.3E-03**	**1.6E-03**
		4-6'	7.4	7.0E-05	na		na		2.4	1.1E-04	1.8E-04
		6-8'	4	3.8E-05	na		na		0.7	3.1E-05	6.9E-05
		8-10'	1.6	1.5E-05	106	1.8E-06	na		u	0.0E+00	1.7E-05
	904-62G	[illegible]	238	**2.2E-03**	73	1.3E-06	na		50	**2.2E-03**	**4.4E-03**
		1-2'	76	7.2E-04	0.8	1.4E-08	na		u	0.0E+00	7.2E-04
		2-4'	85	8.0E-04	na		na		u	0.0E+00	8.0E-04
		4-6'	10.5	9.9E-05	na		na		u	0.0E+00	9.9E-05
		6-8'	34	3.2E-04	na		na		u	0.0E+00	3.2E-04
		8-10'	51	4.8E-04	3	5.2E-08	na		u	0.0E+00	4.8E-04
	904-63G	0-1'	0.34	3.2E-06	0.9	1.6E-08	na		u	0.0E+00	3.2E-06
		1-2'	0.48	4.5E-06	1.1	1.9E-08	na		u	0.0E+00	4.5E-06
		2-4'	0.1	9.4E-07	na		na		u	0.0E+00	9.4E-07
		4-6'	u	0.0E+00	na		na		u	0.0E+00	0.0E+00
		6-8'	0.3	2.8E-06	na		na		u	0.0E+00	2.8E-06
		8-10'	u	0.0E+00	0.7	1.2E-08	na		u	0.0E+00	1.2E-08

Notes:
1) Concentrations shown are averages
2) u = not detected
3) na = not analyzed
4) Pu = Pu-238 and Pu-239/240
5) bbb is below basin bottom
6) risk >1.0E-03 is Principal Threat Source Material (PTSM)
7) **PTSM is BOLDED**
8) [illegible]
9) PRSB data is from 1978
10) Tritium data is not included because it is not analyzed as a soil constituent.

they received less of the discharge. This is especially evident in basin 3 at both CRSB and PRSB, which are minimally contaminated. The distribution of the key radionuclides based on the existing data is presented in Table 6.

The risk values exceeding 1 x 10^{-3} are bolded. For the purposes of the plug-in ROD, soils with radionuclide contaminants exceeding this risk value represent PTSM. The reactor seepage basins primarily differ from the OFASB and LAOCB in that they have significantly lower levels of transuranic radionuclides such as uranium and plutonium. However, this does not impact the application of the common remedy.

Based on risk calculations already completed at KRSB (WSRC 1998a), the risk to the future hypothetical worker is 2 x 10^{-2} . This risk almost exclusively results from external exposure to cesium-137, given an exposure concentration of 2,510 pCi/g. Given the cesium-137 concentration at PRSB (WSRC 1998c) and CRSB (WSRC 1998b), the estimated risks at these units are about 1 x 10^{-2} and 3 x 10^{-3} , respectively. These risks are comparable to those calculated for the OFASB and LAOCB and, based on using the risk value of 1 x 10^{-3} as a threshold from US EPA guidance (1991a), meet the definition of PTSM.

The COCs are traditionally defined in the Remedial Investigation/Baseline Risk Assessment (RI/BRA) report as unit-related constituents that contribute to risks to an industrial worker exceeding one additional potential cancer in a million (1 x 10^{-6}) or potential chronic effects due to toxicity (exceeds a hazard quotient of 0.1). COCs also include constituents that have the potential to leach from soils to groundwater at levels that could exceed maximum contaminant levels in groundwater.

Tritium is a unique potential COC in that it is not sorbed to the basin soils. If present in the vadose zone, tritium is present in the pore water (or soil moisture). Tritium within the vadose zone pore water will mitigate to the water table over time based on the infiltration rate of water.

Based on a typical pore-water velocity, depth to groundwater, and the time elapsed since the candidate units received effluent discharges, it is expected that the tritium has passed entirely through the vadose zone into the groundwater beneath the basins at all the candidate units except for possibly CRSB. Some residual tritium may be present beneath CRSB just above the water table, since the distance to groundwater is greater than the other basins. Additional unit-specific detail on tritium will be provided in the technical evaluation report for each candidate unit.

The COCs for the Plug-in ROD are expected to be primarily radionuclides (the COCs at KRSB based on the RI/BRA were americium-241, carbon-14, cesium-137, cobalt-60, plutonium-239/240, and strontium-90). COCs will be established in the technical evaluation report for each unit based primarily on PTSM criteria, and also considering the CSM, and comparison against the human health and contaminant migration remedial goals (RGs) established in this ROD.

5.4 Conclusion

Based on the similarities between the physical settings and the nature and extent of contamination at OFASB, LAOCB, and the open reactor seepage basins, it is evident that the open reactor seepage basins fit the common CSM and that a common remedy, including treatment of highly contaminated soils, is warranted.

In situ stabilization with a low permeability soil cover system is the preferred alternative for radiologically contaminated units exhibiting characteristics common to the generic CSM. This alternative was evaluated against the nine CERCLA criteria and was found to be protective of human health and the environment, compliant with ARARs, and cost-effective. The summary of this comparison was presented in Table 4. Use of this plug-in remedy will

- streamline the cleanup process,
- employ remedial actions already selected for similar OUs with minimal additional documentation and alternatives analysis, and
- meet the CERCLA preference for treatment and enhance the long-term effectiveness of the remedy.

6.0 DESCRIPTION OF THE COMMON REMEDY

This section will establish the common RAOs to be met at any candidate unit, describe in detail the common remedy, in situ stabilization with a low permeability soil cover system, and demonstrate how the plug-in remedy meets the RAOs.

6.1 Remedial Action Objectives

RAOs consist of medium-specific or OU-specific goals for protecting human health and the environment. The RAOs specify the COCs, the exposure routes (environmental media) and receptors, and an acceptable contaminant level or range of levels (remedial goals) for each exposure route. Remedial goals (RGs) are developed based on ARARs or other information such as risk-based concentrations (RBCs). The remedy is concerned only with the source control OU and will, therefore, not develop RAOs for cleanup of the groundwater.

Based on the characteristics and CSM for the candidate units, the following RAOs have been developed:

(RAO 1) Prevent human exposure to highly contaminated basin soils (PTSM) by performing stabilization treatment to the extent practicable and filling the basins. Reduce risks to the future worker from surface soils (0 to 0.3 m [0 to 1 ft]) outside the basin by establishing RGs for COCs at concentrations equivalent to 1 x 10^{-6} for carcinogens and a hazard quotient of 1 for non carcinogens or background (where background levels of COCs exceed 1 x 10^{-6}).

(RAO 2) Prevent the release of COCs in soil to groundwater beneath the unit above MCLs or RBCs (when MCLs are not available). The soil RGs are back calculated based on these values.

(RAO 3) Protect the ecological receptors indigenous to the area by preventing or limiting contact with contaminated basin soils and pipelines and preventing plants and animals from bringing contaminants up toward the surface.

With respect to the first RAO listed above, nearly all of the contamination associated with the reactor seepage basins is found at the basin bottom, typically 3 to 3.6 m (10 to 12 ft) below grade. A baseline risk assessment evaluates exposure to this contamination as surficial, since the basins are open. The highly contaminated soils in the basin bottoms can be considered PTSM. PTSM is defined by the US EPA as follows (US EPA 1991a):

“Principal threat wastes are those source materials considered to be highly toxic or mobile that generally cannot be reliably contained or would present a significant risk to human health or the environment should exposure occur. They include liquids and other highly mobile materials (e.g., solvents) or materials having high concentrations of toxic compounds. No "threshold level" of toxicity/risk has been established to equate to "principal threat." However, where toxicity and mobility of source material combine to pose a potential risk of 10^{-3} or greater, generally treatment alternatives should be evaluated."

For the purposes of this plug-in remedy only, PTSM is defined as those highly contaminated basin sediments and any other unit-related soils that pose a radiological risk (using baseline risk assessment exposure assumptions) to a future industrial worker equal to or greater than 1×10^{-3}. Based on the presumptive approach used in this ROD and the previous decisions, a bias for treatment of PTSM will be used. Application of the remedy will stabilize the PTSM to the extent practicable. This will convert the waste into a form less likely to result in human exposure. The basins will also be filled to grade, eliminating this surficial exposure pathway.

Any soils contamination associated with the pipelines (if leaking) will generally be below 0.6 in (2 ft) (the depth of the pipelines), thus the probability of any surficial contamination is low. This conclusion is consistent with data from LAOCB, OFASB (except for the discharge ditch), and KRSB. However, the necessary data will be collected for all candidate units for confirmation and to demonstrate that the RGs associated the first RAO are met. Regardless of depth, if contaminated soils exceed PTSM criteria, they will be consolidated in the primary discharge basin and stabilized. The methodology for determining the RGs outside of the basins is, described in detail in Appendix E. Back-calculated RGs for the radionuclides are included in that appendix.

The second remedial action objective specifically requires soil COCs to be addressed so that the groundwater is protected to meet MCLs or RBCs, if MCLs are not available. The combination of in situ stabilization of PTSM and a low permeability soil cover has been demonstrated to be effective in meeting this RAO (WSRC 1997b and 1997c). In addition, a calculation will be performed to determine whether a low permeability soil cover (1 x 10^{-5} cm/s) will be adequate to prevent groundwater impact. The migration of tritium, if present beneath the basins in the vadose zone pore water, will be minimized through the use of a low-permeability soil cover. For those contaminated soils that will not be stabilized outside of the basin(s), it will be necessary to determine if action needs to be taken to protect groundwater. Based on the target groundwater RGs, acceptable residual soil contamination levels ran be conservatively back calculated. Calculation of these soil leachability remedial goals (SLRGs) will be conducted on a unit-specific basis, since the SLRGs depend on unit-specific variables such as the thickness of the source contamination, the depth to the water table, and the groundwater velocity. The unit-specific SLRGs will be presented in the unit-specific decision document.

Appendix D presents the methodology for the back calculation in detail. The remedial action objective is to prevent leaching of constituents to groundwater above MCLs or RBCs if MCLs are not available. The approaches for back calculating the acceptable soil limits based on these target remedial goals in groundwater are consistent with US EPA guidance (US EPA 1996a and 1996b). For radionuclides, the target remedial goals are set to existed and proposed standards. The 4 mrem/yr. standard is used for beta particle and photon (gamma) emitters, except as specified for tritium and strontium-90. Based on this dose standard, an equivalent water concentration (activity) is calculated as required by 40 CFR 141.16 (*Safe Water Drinking Act*). For alpha emitters, the existing final standard for radium-226 and radium-228 (5 pCi/L), the proposed standard for total uranium (20 µg/L), and the existing final standard for other alpha emitters (15 pCi/L) are used. For non-radionuclides with no available MCL, the RBC is established based on the incremental excess cancer risk of 1 x 10^{-6} or a hazard quotient of 1.0 for noncarcinogens.

Relevant to the third RAO, the previous ecological assessment for OFASB and LAOCB (WSRC 1997b and 1997c) have concluded that no constituents of potential concern in the soils are estimated to pose significant ecological risk based on their toxicity at the concentration at which they are present. If concentrations of COCs are present above levels of concern for ecological receptors, the consolidation and stabilization of any PTSM soils will ensure that ecological receptors are protected, since human health PTSM thresholds for radionuclides are lower than ecological thresholds . Protection to the ecological receptors indigenous to the area can be achieved by preventing or limiting contact with highly contaminated basin soil/pipelines, and preventing the plant and animals from bringing contaminants up toward the surface. As discussed above, the principal zone of contamination will generally be at least 2.1 to 3.6 m (7 to 12 ft) below the surface subsequent to the remedy, which is below the burrowing depth of all indigenous animals (see references from American Society of Mammalogists). Trees, which could root to those depths, and harvester or fire ants, which are known to have nests potentially deeper than 1.8 m (6 ft), will be controlled as part of the soil cover system maintenance.

6.2 Plug-in Remedy

This plug-in remedy, in situ stabilization with a low-permeability soil cover system, consists of the following five key aspects discussed in detail below: institutional controls, consolidation of contaminated soil outside of the basins and around the pipelines, in situ stabilization, a low-permeability soil cover system, and pipeline grouting.

6.2.1 Institutional Controls

Institutional controls will be applied to all OUs that plug in to this ROD. The specific area of each candidate unit that will fall under institutional controls will be shown in the Land Use Control Implementation Plan (LUCIP) for that unit, in order to ensure that land use is consistent with the exposure assumptions on which the RAOs are based. Institutional controls will be used to support the first RAO discussed above. The institutional controls alternative will require both near- and long-term actions for protection of human health and the environment.

The four preliminary candidate OUs are all in industrial zones as identified on the proposed SRS future land use map of the SRS FFA *Implementation Plan* (WSRC 1996) for both current and anticipated future land use. US DOE has recommended that residential use of SRS land in the vicinity of these OUs be prohibited; therefore, future residential use and potential residential water usage in this area are unlikely. Institutional controls will. be maintained consistent with industrial land use.

In accordance with the US EPA Region IV Land Use Controls Policy, a LUCAP for SRS has been developed. The LUCAP is a programmatic document developed to assure the effectiveness and reliability of the required land use controls for as long as any land use control continues to be required. The selected remedial alternative for these operable units incorporates institutional (i.e., land use) controls and, therefore, a LUCIP for each of the OUs will be developed. The unit-specific LUCIP will be submitted as part of the post-ROD documentation. The LUCIP will detail the implementation, maintenance, and monitoring of the land use control elements for each OU to ensure that the remedy remains protective of human health and the environment. Upon regulatory approval, the unit-specific LUCIP will be appended to the SRS LUCAP.

The primary institutional control objectives necessary to ensure the protectiveness of the preferred alternative are as follows:

- ! prevent contact, removal, or excavation of buried waste or pipelines in the OU areas designated in technical evaluation report and ESD and
- ! preclude residential or agricultural use of the area.

These objectives will be met by near- and long-term land use controls. The following near-term land use controls are expected to prevent exposure to the contaminated media at the plug-in OUS:

- ! SRS boundary security gates prevent exposure to intruders, , ,
- ! visible warning signs at the most probable access points requiring contact of the waste unit custodian prior to entry to the operable unit; and
- ! the site use/site clearance program prevents excavation in the area of the unit pipeline or cover system.

Long-term institutional controls will include evaluation of the need for deed notification/restrictions if the property is ever transferred to non-federal ownership, as required under CERCLA Section 120(h). It is expected that deed restrictions will prohibit residential or agricultural use and excavation activities in the area under institutional control. However, the need for deed restrictions may be reevaluated at the time of transfer in the event that exposure assumptions differ and/or contamination no longer poses an unacceptable risk under residential use.

In addition, a survey plat of the area under institutional controls will be prepared, certified by a professional land surveyor, and included with the LUCIP.

6.2.2 Consolidation

Consolidation of contaminated soils outside of the basins within the AOC of a given unit will be conducted to ensure that the footprint of the OU is reduced to the extent practical. This will reduce both the footprint of the remaining units and the maintenance costs associated with the implementation of the remedy. This is expected to include contaminated soils associated with pipelines (supporting RAO 2), incidentally impacted surface soils such as those found at OFASB (supporting RAO 1), and any PTSM.

Subsurface soil (deeper than 1 ft) containing COCs present at concentrations above contaminant migration RGs will be consolidated. These soil RGs are calculated to prevent migration of contaminants to groundwater for 1,000 years at concentrations that will exceed MCLs. Should the back-calculated soil concentrations protective to these levels be below background concentrations, background concentrations will be used as the RG. This is consistent with the second RAO. Soils present below leachability criteria not meeting this criterion will be left in place. The methodology for this calculation is presented in Appendix D.

For surficial soils, the amount of contaminated soils being consolidated would be driven by the first RAO. Industrial worker exposure RGs for COCs are established at 1×10^{-6} for carcinogens at the surface (0 to 1 ft) or background (where background levels of COCs exceed $1 \times ^{10-6}$) , as required by SCDHEC. Contaminant concentrations of nonradionuclides (if present) would be reduced to acceptable risk levels (HQ=1) for the industrial worker. The methodology for the RG calculations is presented in Appendix E, which also contains a look-up table for the radionuclides.

Any soil to be consolidated that meets the definition of PTSM will be excavated, consolidated into the primary seepage basin for that OU, and stabilized. Soils exceeding RGs that are not PTSM will be placed in the basin before filling to grade, but may not be stabilized.

6.2.3 In Situ Stabilization

In situ soil stabilization is a treatment technology application that reduces the accessibility and mobility of contaminants. It will be applied to soils that are considered to be PTSM. In situ stabilization will support the first and second RAOs.

Stabilization treatment for this principal threat will meet the CERCLA preference for treatment. Stabilization treatment will provide for greater long-term effectiveness in protecting groundwater, and will also serve to augment prevention of potential direct exposure to the PTSM by converting the waste into a form less susceptible to uptake by human intruders.

In situ soil stabilization is performed by injecting or mixing the solidification agents directly into or with the contaminated soil. The two general methods used to deliver the stabilizing agents to the soil include shallow soil mixing (e.g., using crane- or truck-mounted, single-shaft auger heads) or soil injection/jet grouting (e.g., drilling holes to the desired depth and injecting soil stabilizing agents into the soil with high pressure pumps). The type of delivery system used will depend on the unit-specific physical soil properties present.

Solidification agents for injection technologies can be broken into two main categories: suspension grouts and chemical grouts. Suspension grouts are non-Newtonian fluids that consist of finely divided particulate matter suspended in water. Common examples of suspension grout materials include Portland cement and bentonite clay. Application of suspension grouts is limited by the viscosity of the solid/liquid suspension and the size of the suspended particle in relation to the pore size of the soil. The smallest void that can be effectively grouted is no smaller than three times the grain size of the suspended solid. Chemical grouts are Newtonian fluids that can have viscosities as, low as water. These grouts can be injected essentially any place that water can penetrate and as a result, can be used to solidify very fine soil voids. The most common chemical grout material is an aqueous solution of sodium silicate. Stabilization agents will be matched to the contaminants present to maximize the effectiveness of the stabilization agents in reducing mobility.

Unit-specific stabilization details will be provided as part of the remedial design report/ remedial action work plan for each unit.

6.2.4 Low Permeability Soil Cover System

A low permeability soil cover system will be placed over all the open basins. The soil cover system will be designed with permeability low enough to prevent migration of soil contaminants to groundwater for 1,000 years at concentrations that will exceed MCLs. This analysis will be completed in the decision document for each unit. The soil cover system will also help to reduce the migration rate of tritium, if any is still present in the vadose zone pore water. The soil cover system will consist of a layer of soil placed over the contaminated area. The soil used in the cover is clean, native soil selected from a nearby area (it is expected that an SRS borrow pit will be used). The primary purpose of the cover is to reduce the infiltration rate through the contaminated zone and thus reduce contaminant migration, which supports RAO 2. The cover also acts to provide a barrier between potential receptors and the contaminants, which supports RAOs 1 and 3. If the hydraulic conductivity requirements cannot be achieved with compaction of native soil, a combination of geosynthetic materials will be used. These would include a geotextile clay liner, high-density polyethylene geomembrane liner, and a high-density polyethylene geonet (for drainage).

Based on the use of natural materials and its simple structure, the soil cover system can be maintained to provide long-term protection. Typically the soil cover is mounded, feathered into the surrounding area, and vegetated to minimize the impact of erosion. To support RAO 3, the depth to the waste will be at least six feet to prevent inadvertent plant or animal intrusion into the waste through the soil cover system (Suter, et al. 1993). Six feet is conservative based on a review of animal burrowing depths for SRS species (see References section). If a candidate unit is configured such that the depth to PTSM soil is less than six feet, a bio-barrier will be added to the cover system to prevent ecological intrusion. The soil cover system will be maintained to prevent bioturbation by ants and the growth of trees that may have root systems deep enough to reach the PTSM soil. Figure 9 shows a typical cross-section of an open reactor seepage basin and the contaminant pathways. Figure 10 shows a typical cross-section of the same basin with in situ stabilization and a low permeability soil cover system applied.

6.2.5 Pipelines

The pipelines associated with the candidate units will be grouted in place. The pipelines associated with each basin are 3-inch diameter high-density polyethlene. The pipelines will be grouted from the disassembly basin to the exit point at the seepage basin. This action will meet the third RAO by preventing access by small animals. This will also stabilize any potential contamination left inside the pipeline.

6.3 Applicable, or Relevant and Appropriate Requirements (AGARS)

Section 121(d) of CERCLA of 1980, as amended by SARA of 1986, requires that remedial actions comply with requirements or standards set forth under federal and state environmental laws. Requirements or standards may be classified as either applicable or relevant and appropriate. Applicable requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site (US EPA 1988).

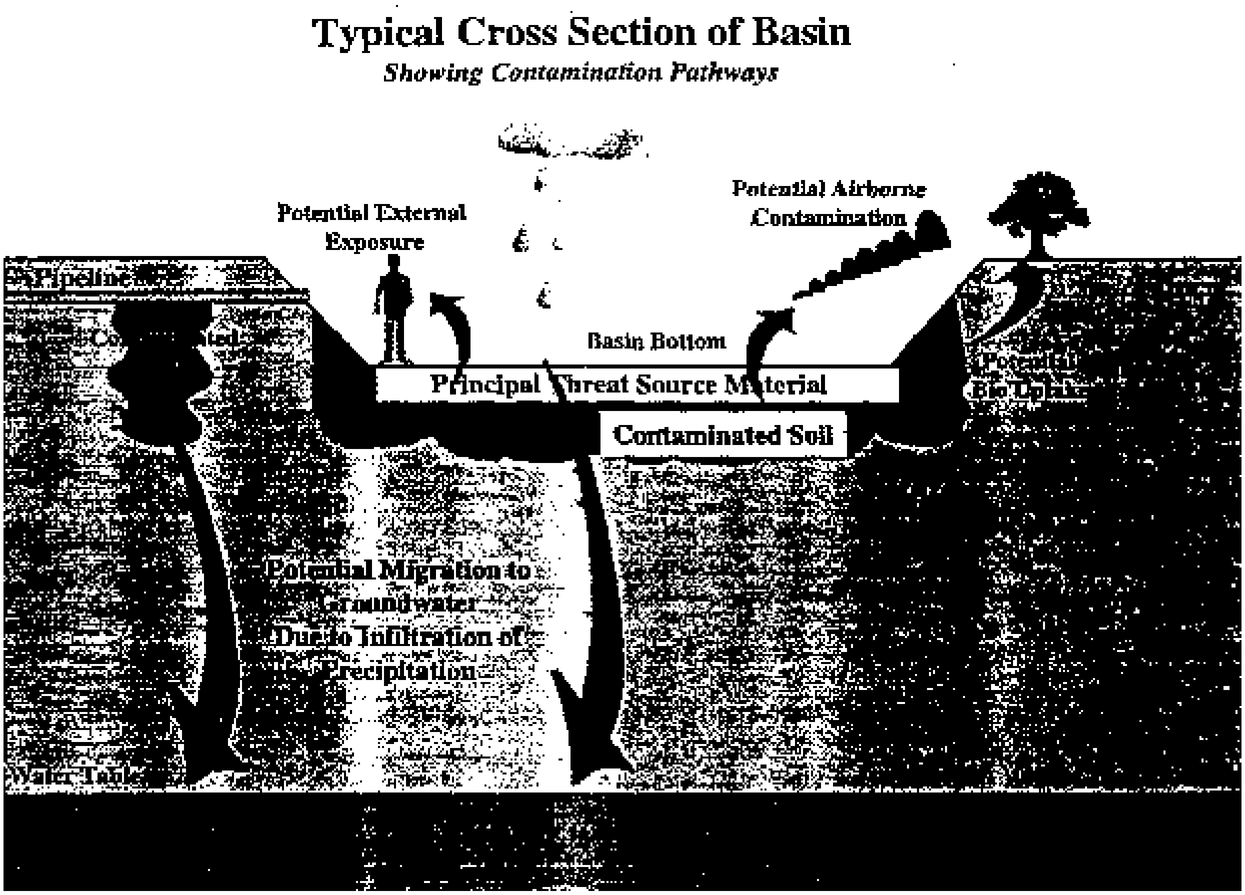


Figure 9. Cross Section of a Typical Basin Showing Contaminant Pathways

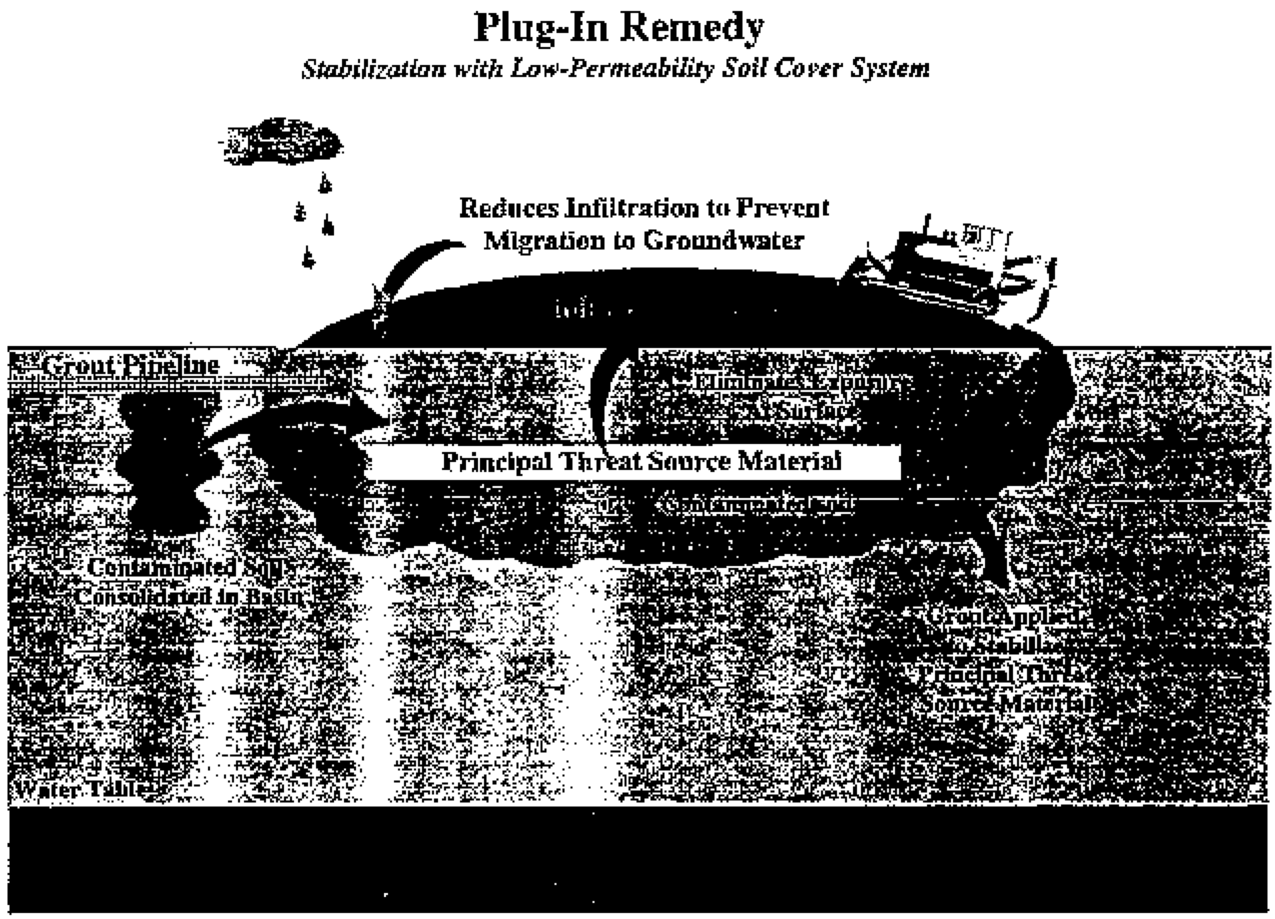


Figure 10. Cross Section of a Typical Rad Basin with Plug-in Remedy Applied

Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that, while not applicable to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site so that their use is well suited to the particular site (US EPA 1988).

In addition to AGARS, many federal and state environmental and public health programs have also developed to-be-considered (TBC) criteria, guidance, and proposed standards that are not legally binding, but that may provide useful information or recommended procedures (US EPA 1988). These TBCs are not AGARS, but are considered when determining remedial action objectives. For example, US DOE orders are not AGARS since they have not been formally promulgated under federal or state law. U S DOE orders are legally binding for US DOE and all of its contractors through the Price Anderson Amendments Act of 1988, which is the amendment to the Atomic Energy Act. US DOE orders for protection of the public and the environment are addressed through compliance with relevant and appropriate federal regulations. Thus, no TBCs are identified for the plug-in ROD.

6.3.1 Types of AGARS

AGARS are classified as being location specific, chemical specific, or action specific to further clarify how to identify and comply with environmental requirements.

Location-specific AGARS must consider federal and state requirements that reflect the physiographical and environmental characteristics of the unit or the immediate area.

Remedial actions may be restricted or precluded based on the location or characteristics of the unit and the resulting requirements. Chemical-specific ARARs are media-specific concentration limits promulgated under federal or state law. Remedial actions must be capable of meeting chemical-specific ARARs. Action-specific ARARs control the design, performance, and other aspects of implementation of specific remedial activities. For example RCRA regulated off site disposal of hazardous residuals.

6.3.2 Identification of ARARs for the Plug in R0D

The following sections identify location-specific, chemical-specific, and action-specific ARARs and TBCs for the Plug-in ROD. Table 7 presents the ARARs for the Plug-in ROD.

6.3.2.1 Location-Specific ARARs

The South Carolina Water Classification Standards (SC. R,61-68) are applicable to the water table aquifers beneath the candidate OUs. The resultant classification of the water table aquifers as potential drinking water sources consequently triggers state groundwater protection standards.

6.3.2.2 Chemical-Specific ARARs

Applicable federal regulations, which establish exposure limits for employees and the public, are promulgated in 10 CFR 835 (*Occupational Radiation Protection*). This regulation, which will apply to remediation workers, also specifies applicable airborne contamination values and personnel exposure control measures (i.e., protective clothing).

Table 7. ARARs

CITATION/REQUIREMENT	REMARKS
CHEMICAL-SPECIFIC	
NRC Requirements for Land Disposal of Radioactive Waste	
10 CFR 61.40 - Maximum annual dose from all pathway of 25 mrem to the whole body, 75 mrem to thyroid. and 25 merm to any other organ of any member of the public, including ALARA	Relevant and appropriate regulation. This regulation is intended for the same types and levels of radionuclides that will remain in the operable units that are managed in facilities regulated under 10 CFR 61. Cleanup levels for radionuclides to be left in place must at least meet these levels. This remedy meets 1 x 10^{-6} cleanup levels, which are lower than those based on 10 CFR 61.
SC Radioactive Material Regulations	
R.61-63, 7.19- Protection of Individuals from Inadvertent Intrusion. Closure of land disposal facility shall prevent inadvertent intrusion into the site, or contact with the waste after active institutional controls are removed.	Relevant and appropriate regulation. This regulation is intended for the same types and levels of radionuclides that will remain in the operable units as after the closure of a state- licensed facility for land disposal of radioactive waste. Deed restrictions and stabilization of PTSM will meet intent of this regulation.
R.61-63, 7.18- Protection of the General Population from Releases of Radioactivity. Maximum dose from all pathways of 25 mrem to the whole body, 75 mrem to thyroid. and 25 mrem to any other organ of any member of the public, including ALARA principles.	Relevant and appropriate regulation. This regulation is intended for the same types and levels of radionuclides that will remain in the operable units as after the closure of a state licensed facility for land disposal of radioactive waste. Cleanup levels for radionuclides to be left in place must at least meet these levels.. This remedy meets 1 x 10^{-6} cleanup levels, which are lower than those based on 10 CFR 61.
40 CFR 141 - MCLs and MCLGs for groundwater that may be a source of drinking water	Relevant and appropriate regulation. This standard for maintaining quality of groundwater that could be used as a drinking water source. Used as basis to back calculate soils' RGs to prevent future leaching to groundwater at unacceptable levels.
SC R.61-58.5 - MCLs and MCLGs for groundwater that may be a source of drinking water	Relevant and appropriate standards for maintaining quality of groundwater through source controls Used as basis to back calculate soils' RGs to prevent future leaching to groundwater at unacceptable levels.
Occupational Radiation Protection	
10 CFR 835.202 - Max. exposure for employees of 5 rem/yr.	Applicable regulation to workers during remediation activities.
10 CFR 835.206 - Exposure limits for embryo/fetus of 0.5 rem	Applicable regulation to workers during remediation activities.
10 CFR 835.208 - Exposure limits for members of the public during direct on-site access shall not exceed 0.1 rem TEDE	Applicable regulation to workers during remediation activities.

Table 7. ARARs (Continued)

CITATION/REQUIREMENT	REMARKS
LOCATION-SPECIFIC ARARs	
Drinking Water Standards	
Clean Air Act	
40 CFR 61.92 - Emissions of radionuclides to the ambient air from US DOE facilities shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent of 10 mrem/yr	Applicable during construction activities.
SC Water Classification Standards	
SC R. 61-68. - Definition of and classification of state groundwaters.	Relevant and appropriate standard for the classification of groundwater in the state, which subsequently triggers state groundwater protection standards. Used as basis to back calculate soils Rgs to prevent future leaching to groundwater at unacceptable levels
ACTION-SPECIFIC ARARs	
National Environmental Policy Act	
10 CFR 1021 - National Environmental Policy Act - Implementing procedures and guidelines	Applicable regulation to remedial actions. Met by categorical exclusion for CERECLA remedial actions.
SC Storm Water Regulations	
SC R. 72-300 - Storm Water Management and Sediment Reduction Regulation. Section 305 specifies a Stormwater Management and Sediment Control Plan required for any land disturbing activities.	Applicable regulation to construction activities. Compliance with this regulation will also meet federal Clean Water Act regulations. Must be considered during soil cover system design and followed during construction activities.

Applicable federal regulations for ambient air emissions of radionuclides are promulgated in 40 CFR 61.92 (*Clean Air Act*). This applicable regulation protects the general public during remediation activities.

Relevant and appropriate regulations for the protection of groundwater include the federal regulations in 40 CFR 141 (*Safe Water Drinking Act*) and South Carolina drinking water regulations promulgated in SC R.61-58.5. MCLs derived from these regulations are the targets that cannot be exceeded in back-calculating acceptable residual levels of contamination in the soil.

In establishing soil remedial goals at the surface, two relevant and appropriate regulations are identified: 1) 10 CFR 61.40 (NRC *Requirements for Land Disposal of Radioactive Waste*), and 2) SC R.61-63 (*South Carolina Radioactive Material Regulations*). 10 CFR 61.40 and SCR 61.63 establish the maximum allowable annual those to the public at 25 mrem/yr to the whole body, 75 mrem/yr to the thyroid, or 25 mrem/yr to any critical organ. SC R.61-63 also specifies exposure limits for employees and airborne contamination. 10 CFR 20, a more recent regulation concerning post-closure unrestricted use of a facility, was not considered because it is less protective than 10 CFR 61.40.

SCDHEC does not consider these ARARs to be protective enough. Therefore, RGs for surficial exposure to radionuclides have been set at 1 x 10^{-6} or background, if .background risk levels for COCs exceed 1 x 10^{-6}. Since the 1 x 10^{-6} RGs are significantly lower than the RGs would be if they were ARAR-based, the ARARs will be met for all radionuclides. The details for the methodology for the back calculation of both ARAR-based and risk-based RGs are provided in Appendix E.

6.3.2.3 Action-Specific ARARs

Applicable environmental regulations for construction activities during remediation include 10 CFR 1021 (National Environmental Policy Act), and SC R.72-300 (*Storm Water Management and Sediment Reduction*). The small scale of the remediation activities will result in these actions being classified as categorical exclusions under the National Environmental Policy Act (NEPA), consistent with other CERCLA actions at the SRS. Fill material for the soil cover will be obtained from existing on site borrows pits. Compliance with the.South Carolina Storm water management sediment reduction regulation will also meet federal Clean Water Act regulations. Specifically, SC R.72-305 requires a Stormwater Management and Sediment Control Plan for any land-disturbing activities. The Occupational Safety and Health Administration (OSHA) regulations are not generally considered environmental regulations and, therefore, are not identified as ARARs for the plug-in remedy. However, all remediation activities will be required to comply with OSHA regulations.

6.4 Costs

Table 8 summarizes the estimated costs for applying the remedy to each of the four OUs. The costs are broken down into four general categories: 1) the soil cover system, 2) in situ stabilization, 3) engineering, construction, and other project support services, and 4) operation and maintenance, including 5-year remedy reviews. These costs are preliminary and considered to be feasibility study type estimates that are +50% -30% accurate.

At LRSB, it is assumed that the first 0.6 m (2 ft) of soil from the basin bottom will require in situ stabilization. At KRSB, it is assumed that the first 0.9 m (3 ft) of soil from the basin bottom will require in situ stabilization. At CRSB, it is assumed that the first 1.8 m (6 ft) of soils from the basin bottom in basin #1 and 1.2 m. (4 ft) of soil from the basin bottom in basin #2 will require in situ stabilization. At PRSB, it is assumed that the first 1.2 m (4 ft) of soil from the basin bottom in basins #1 and #2 will require in situ stabilization. The estimates at LRSB and PRSB will be refined as additional data is collected.

A discussion of the cost-effectiveness of the remedy is provided in Section 4.0.

Table 8. Estimated Costs for In Situ Stabilization with a Soil Cover System for the Candidate OUs

Cost Category	LRSB	KRSB	CRSB	PRSB
Soil Cover System	$203,366	130,939	$883,151	$845,617
In Situ Stabilization	1,004,991	$982,879	$2,864,706	$2,034,573
Engineering and Other Service	$740,458	$740,458	$895,491	$895,491
Operation and Maintenance	$566,268	$458,813	$1,515,515	$1,249,383
Total	**$2,515,083**	**$2,313,089**	**$6,158,863**	**$5,025,064**

7.0 PLUG-IN DECISION PROCESS

This section (1) describes the plug-in criteria to determine if a candidate unit can use the plug-in ROD (2) summarizes the administrative mechanics of using the plug-in ROD, and (3) provides a preliminary evaluation of the KRSB, CRSB, PRSB, and LSRB against the plug-in criteria. The basic process for the plug-in ROD is shown in Figure 11.

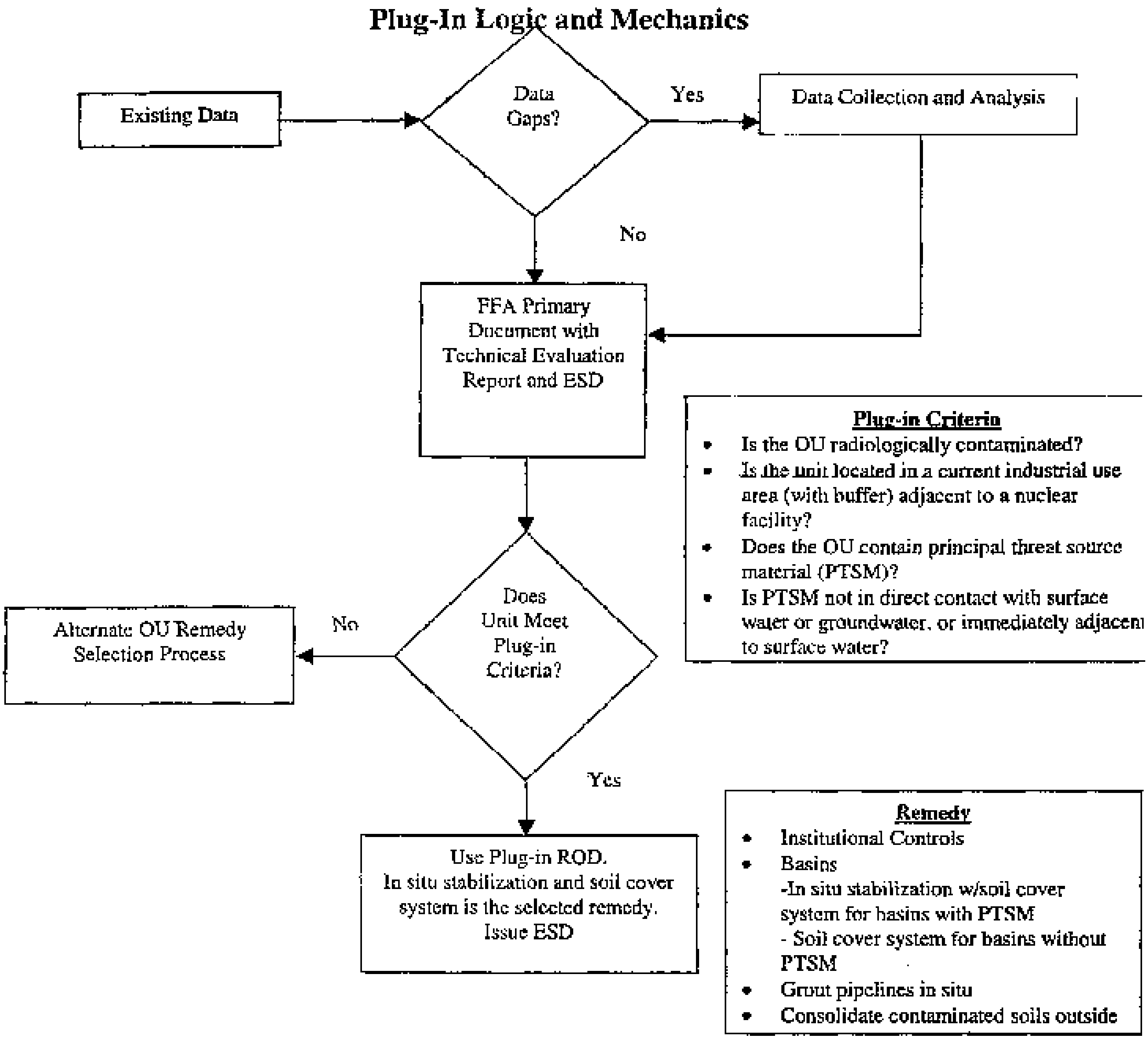


Figure 11. Plug-in Logic and Mechanics

7.1 Plug-in Criteria

The plug-in criteria are used to ensure that the waste units match the conditions that the plug-in remedy has been designed to meet. Therefore, the threshold criteria have been developed based on the conditions for which in situ stabilization with a low permeability soil cover system is technically effective and the conditions for which SRS precedents have established in situ stabilization with a low permeability soil cover system as a preferred response action.

The plug-in criteria have been formulated as key questions that the decision-makers (US DOE, US EPA and SCDHEC) must consider when evaluating a unit for a plug-in. Figure 12 shows a plug-in criteria logic flowchart. If the answer to any of the four questions is "No," then this plug-in ROD is not directly appropriate and an alternate OU remedy selection process will be used. If the candidate unit will receive waste from another operable unit, the decision to transfer the waste under the proper documentation should take place before the unit is evaluated for the plug-in ROD remedy.

Question 1 - Is the unit radiologically contaminated?

The signed RODs for the OFASB and the LAOCB both indicate that on-unit containment is the preferred response for addressing threats posed by radiologically contaminated soils. The primary contaminants at the unit should be radionuclides. Should no radionuclides be found at the unit, then the plug-in ROD would not be applicable because no SRS precedent has been established for using in situ stabilization with a low permeability soil cover

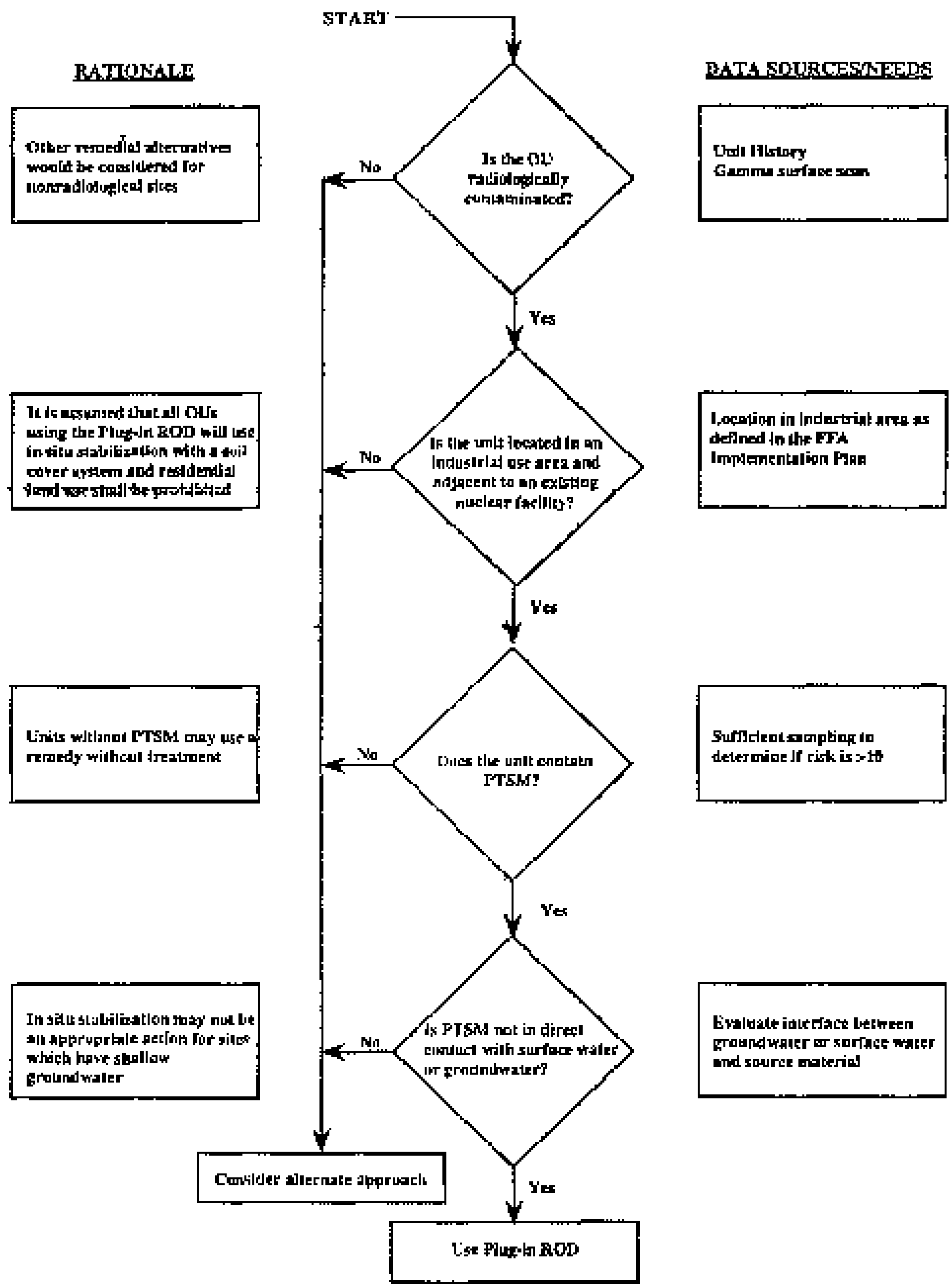


Figure 12. Plug-in Criteria for the Plug-in ROD

system at nonradioactively contaminated units. Units with nonradionuclides as the primary risk drivers would be evaluated on a case-by-case basis.

Question 2 - Is the unit located in a current industrial use area (with buffer) adjacent to an existing nuclear facility?

During the development of the RAOs, one of the key assumptions was that land use controls that would not allow unrestricted use would be placed on the OUs. This assumption was made because applying in situ stabilization with a low-permeability soil cover system will leave contaminants in place, at levels which preclude unrestricted use. At the present time, agreement has been reached that the areas around the current industrial use area (with buffer) adjacent to a nuclear facility (e.g., the reactor facilities, see Figure 3) will be used in the future only for industrial uses (WSRC 1995 and US DOE 1996a). Therefore, if the unit meets these location criteria, it meets the requirements for industrial future land use and satisfies the assumptions of the RAOs.

Question 3 - Does the unit contain PTSM?

This plug-in ROD is biased toward active remediation and treatment of units known, or expected, to present a significant threat to human health and the environment. If the unit does not contain PTSM as defined in this ROD (risk to a future industrial worker equal to or greater than 1 x 10^{-3}), the OU does not plug in since additional remedial alternatives without treatment should also be considered.

Question 4 - Is PTSM not in direct contact with surface water or groundwater or immediately adjacent to surface water?

The two cases to be considered are groundwater intrusion into the PTSM and surface water proximity to the waste such that the PTSM or the soil cover system could be eroded over time. The long-term stability of stabilized soils in the saturated zone would have to be further evaluated. These situations would preclude the use of this remedy unless engineering controls were first implemented to mitigate the problem. After the engineering controls were completed to prevent contact of PTSM with surface water or groundwater, the Plug-in remedy could be evaluated for use at a candidate unit. Should contaminated soils extend down through the vadose zone to the water table, the efficacy of the remedy will be addressed in the technical evaluation report for that unit.

7.2 Mechanics of Plugging an OU in

In order to determine if an OU meets the criteria of this plug-in ROD, the historical data will be evaluated, and adequate field characterization data will be collected and analyzed. The evaluation of an OU to determine if it meets the criteria of this plug-in ROD will be summarized in a proposed ESD and a technical evaluation report.. A generic example of the technical evaluation report is found in Appendix B. The technical evaluation document will be submitted with a primary CERCLA document (e.g., Workplan) for the OU. However, for KRSB and CRSB the ESD and technical evaluation report will be submitted as stand-alone documents, since these two units have already had work plans submitted.

Once the three parties agree that the unit meets the criteria contained in this plug-in ROD, the proposed ESD will be issued for a 30-day public comment period. An ESD typically describes a significant difference in the remedy from that described in the ROD. For the plug-in ROD, it will serve to document use of the plug-in remedy at a specific operable unit. Any public comments will be addressed in the final ESD, and a public notice of the final ESD will be issued.

7.3 Preliminary Evaluation of the Four Reactor Seepage Basins Against the Plug-in Criteria

A preliminary evaluation of the four OUs against the plug-in criteria is presented in Table 9. Based on this preliminary evaluation against the plug-in criteria, CRSB, KRSB, and PRSB would meet the plug-in criteria.

LRSB will require additional data to determine if the unit can use the plug-in ROD. The existing data for PRSB is about 10 years old. Additional data will be required to support the detailed application of the remedy. The decision to plug these preliminary candidate units into the plug-in ROD will be fully documented in an ESD and associated technical evaluation report.

Table 9. Preliminary Evaluation of the Four Reactor Seepage Basins

Preliminary Candidate Operable Unit	Criteria 1: Is the OU radiologically contaminated?	Criteria 2: Is the OU in a current industrial use area (with buffer) adjacent to a current nuclear facility?	Criteria 3: Does the OU contain (PTSM)?	Criteria 4: Is the PTSM not in direct contact with groundwater or immediately adjacent to surface water?
C-Area Reactor Seepage Basins (904-066G, -067G, -068G)	**Yes,** based on past process history and sampling.	**Yes** (see Figure 4)	**Yes,** radionuclide contaminant concentrations > PTSM threshold of 1E-03 risk.	**Yes,** groundwater is 21 m (70 feet) below the ground surface. No adjacent surface water features.
K-Area Reactor Seepage Basins (904-65G);	**Yes,** based on past process history and sampling.	**Yes** (see Figure 5)	**Yes,** radionuclide contaminant concentrations > PTSM threshold of 1E-03 risk.	**Yes,** groundwater is 18 m (60 feet) below the ground surface. No adjacent surface water features.
L-Area Reactor Seepage Basins (904-64G)	**Yes,** based on past process history.	**Yes** (see Figure 6)	**Insufficient data available.** Assuming radionuclide contaminant concentrations will be > PTSM threshold of 1E-03 risk.	**Yes,** groundwater is 7.4 m (24 feet) below the ground surface. No adjacent surface water features.
P-Area Reactor Seepage Basins (904-61G, -62G, -63G)	**Yes,** based on past process history and sampling.	**Yes** (see Figure 7)	**Yes,** radionuclide contaminant concentrations > PTSM threshold of 1E-03 risk.	**Yes,** groundwater is 12.2 m (40 feet) below the ground surface. No adjacent surface water features.

8.0 HIGHLIGHTS OF COMMUNITY PARTICIPATION

CERCLA requires that the public be given an opportunity to review and comment on the proposed remedial alternative. CERCLA provides public input through the PP comment period. Public participation requirements are listed in Sections 113 and 117 of CERCLA. These requirements include establishment of an Administrative Record File that documents the investigation and selection of the remedial alternatives for addressing the soil and groundwater. The Administrative Record File must be established at or near the facility at issue. The SRS public involvement plan (US DOE 1994) is designed to facilitate public involvement in the decision-making process for permitting, closure, and the selection of remedial alternatives. The SRS public involvement plan addresses the requirements of CERCLA and the National Environmental Policy Act. Section 117(a) of CERCLA, as amended, requires the advertisement of the draft permit modification and notice of any proposed remedial action and provide the public an opportunity to participate in the selection of the remedial action.

The Administrative Record File, which contains the information pertaining to the selection of the response action, is available at the US EPA office in Atlanta and at the following locations:

U.S. Department of Energy
Public Reading Room
Gregg-Graniteville Library
University of South Carolina-Aiken
171 University Parkway
Aiken, South Carolina 29801
(803) 641-3465

Reese Library
Augusta State University
2500 Walton Way
Augusta, Georgia 30910
(706) 737-1744

Thomas Cooper Library
Government Documents Department
University of South Carolina
Columbia, South Carolina 29208
(803) 777-4866

Asa H. Gordon Library
Savannah State University
Tompkins Road
Savannah, Georgia 31404
(912) 356-2183

The SRS Citizens Advisory Board has had the opportunity to provide input into the plug-in ROD concept and has passed two motions to implement this concept at SRS. Recommendation #2 stated that the plug-in ROD remedy should be applied to all sites that meet the plug-in criteria. Recommendation #76 added that the plug-in remedy should be specifically applied at the candidate units identified in this ROD. The public was notified of the public comment period through mailings of the *SRS Environmental Bulletin*, a newsletter sent to approximately 3500 citizens in South Carolina, Georgia, and several other states, and through notices in the *Aiken Standard*, the *Allendale Citizen Leader*, the *Augusta Chronicle*, the *Barnwell People-Sentinel*, and *The State* newspapers.

The 45-day public comment period on the Plug-in Proposed Plan began on June 12, 1999 and ended on July 26, 1999. No public comments were received.

For each candidate unit evaluated for the plug-in ROD, an ESD will be made available for a 30-day public comment period. The technical evaluation report, which will provide the technical detail used to prepare the ESD, will be available through the Administrative Record File. If the three agencies agree that the plug-in remedy should be used for the candidate unit, any public comments will be addressed, the ESD will be finalized, and a public notice will be issued.

9.0 STATUTORY DETERMINATIONS

Based on previous evaluations for similarly contaminated OUs the OFASB and the LAOCB and the existing data available, the radiologically contaminated candidate OUs identified within this ROD pose significant risk to human health. Therefore, actual or threatened releases of radionuclides and hazardous constituents from these units, if not addressed by implementing the response action selected in this ROD, may present an imminent and substantial endangerment to public health, welfare, or the environment.

For waste units meeting the plug-in criteria, the selected remedy is protective of human health and the environment, complies with federal and state requirements that are legally applicable or relevant and appropriate to the remedial action, and is cost-effective. This remedy utilizes permanent solutions and alternative treatment (or resource recovery) technology to the maximum extent practicable, and satisfies the statutory preference for remedies that employ treatment to reduce toxicity, mobility, or volume as a principal element. Contaminated basin sediments and soils identified as PTSM will be in-situ stabilized. Application of a low permeability cover system will prevent exposure of human and ecological receptors to highly contaminated soils. Soils exceeding human health or leachability RGs outside the basin will be consolidated into the most contaminated basin. The levels of radionuclides in the soil warrant a common remedy in which institutional controls are a required aspect of the remedy. In situ stabilization with a low permeability soil cover system is considered a short- and long-term permanent solution.

Section 300.430 (f)(4)(ii) of the National Oil and Hazardous Substances Pollution Contingency Plan requires that if hazardous substances, pollutants, or contaminants above levels that allow for unlimited use and unrestricted exposure remain in the waste operable unit. The action must be reviewed no less than every five years after its initiation. Because this remedy will result in hazardous substances remaining onsite above levels that allow for unlimited use and unrestricted exposure, the three parties (US DOE, SCDHEC, and US EPA) have determined that a five-year review of any decision made to use the plug-in interim ROD will be performed to ensure continued protection of human health and the environment.

10.0 EXPLANATION OF SIGNIFICANT CHANGES

The PP provided for involvement with the community through a document review process and a public comment period. No public comments were received.

The three parties decided to expand the public participation process in determining if a candidate unit meets the plug-in criteria, and should, therefore, use the plug-in remedy. The proposed plan indicated that for the four reactor seepage basins, the public would be notified that the OU met the plug-in criteria and was using the plugin remedy. The public will now be given a 30-day public comment period for all candidate operable units before a decision is made by US DOE, US EPA, and SCDHEC to use the plug-in remedy.

The proposed plan specified that near-term institutional controls would limit land use activities at the unit for the next 100 years to monitoring and maintenance activities. This ROD has revised the remedial goals for cleanup of potential contamination outside of the basins to allow for any industrial use excluding excavation or other activities that would disturb the cover system.

11.0 RESPONSIVENESS SUMMARY

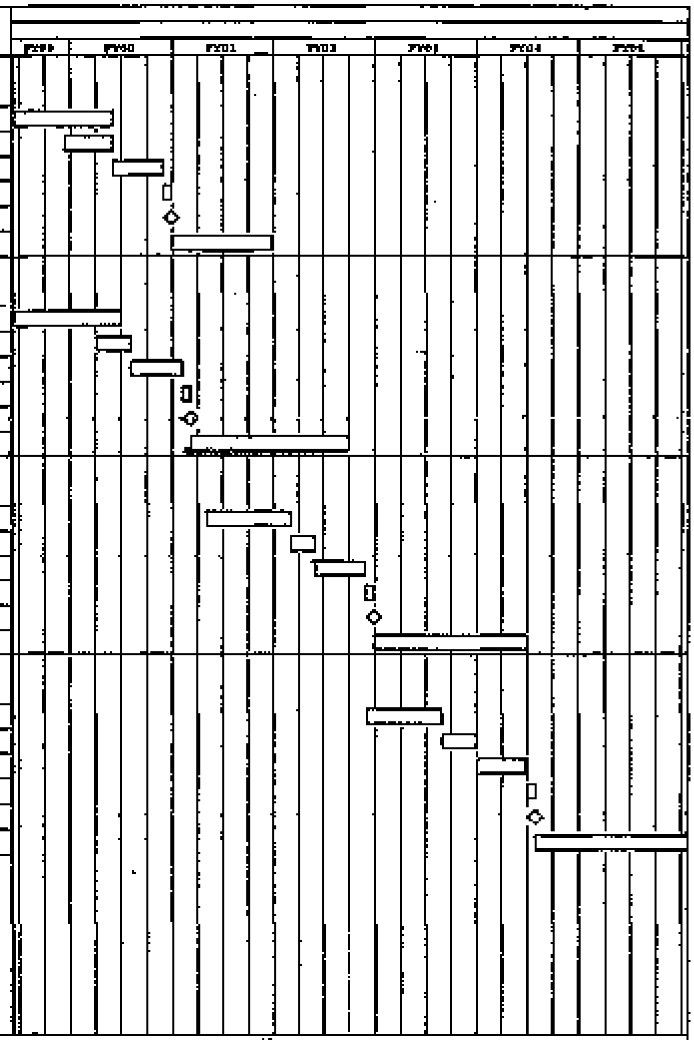
No comments were received during the public comment period and, therefore, no responsiveness summary is required.

12.0 POST-ROD DOCUMENT SCHEDULE

A technical evaluation report and a proposed ESD, will be developed for each candidate unit that identifies the appropriateness of a given OU to use the plug-in remedy. Following public comment and final approval of the ESD, unit-specific post-ROD documents will be developed. It is expected that a single post-ROD document containing design information and remedial action implementation details will be submitted before the remedial action. A remedial action report will be submitted after the implementation of the remedial action.

Figure 13 represents the planning case for applying the plug-in approach to the four reactor seepage basins. Implementation schedules for individual source units will be placed in unit-specific documents. A FFA compliance date of January 31, 2001 has been established for the L-Area Reactor Seepage Basin Operable Unit work plan submittal. The work plan will include the proposed ESD and technical evaluation report provided the operable unit meets the plug-in criteria. The planning date for the submittal of the P-Area Reactor Seepage Basin Operable Unit work plan, is August 31, 2002.

ACTIVITY DESCRIPTION	EARLY START	EARLY FINISH	ORIG DUR
K-REACTOR SEEPAGE BASIN			
ESD/TER (REVIEW/REVISE/APPROVAL)	10MAR99	29FEB00	357
POST ROD DOC PREP	9SEP99	28FEB00	173
POST ROD DOC (REVIEW/REVISE/APPROVAL)	29FEB00	28AUG00	182
MOBILIZATION	29AUG00	27SEP00	30
RA START	28SEP00		0
REMEDIATION	28SEP00	26SEP01	364
C-REACTOR SEEPAGE BASIN			
ESD/TER (REVISE/REVIEW/APPROVAL)	10MAR99A	30MAR00	387
POST ROD DOC PREP	3JAN00	5MAY00	124
POST ROD DOC (REVIEW/REVISE/APPROVAL)	6MAY00	7NOV00	186
MOBILIZATION	8NOV00	7DEC00	30
RA START	8DEC00		0
REMEDIATION	8DEC00	28JUN02	568
L-REACTOR SEEPAGE BASIN			
WORKPLAN WITH ESD/TER (REVIEW/REVISE/APPROVAL)	31JAN01	29NOV01	303
POST ROD DOC PREP	30NOV01	27FEB02	90
POST ROD DOC (REVIEW/REVISE/APPROVAL)	28FEB02	26AUG02	180
MOBILIZATION	27AUG02	25SEP02	30
RA START	26SEP02		0
REMEDIATION	26SEP02	31MAR04	553
P-REACTOR SEEPAGE BASIN			
WORKPLAN WITH ESD/TER (REVIEW/REVISE/APPROVAL)	1SEP02	28MAY03	270
POST ROD DOC PREP	29MAY03	30SEP03	125
POST ROD DOC (REVIEW/REVISE/APPROVAL)	1OCT03	28MAR04	180
MOBILIZATION	29MAR04	27APR04	30
RA START	28APR04		0
REMEDIATION	28APR04	25OCT05	546



Plot Date 16SEP99
Data Date 10AUG99
Project Start 15SEP97
Project Finish 25OCT05

(c) Primavera Systems, Inc.

K,C,L,P RX SB CANDIDATE PLUG-IN SOURCE UNITS
PLANNING SCHEDULE ONLY

* Does not represent compliance case.

Date	Revision	Checked	Approved

Figure 13. Planning Generic Schedules for KRSB, CRSB, PRSB, and LRSB

CERCLA Sec. 120(e)(2) requires continuous physical onsite remedial action within 15 months of the "completion of the investigation and study". For the purpose of assessing compliance for the plug-in ROD units, the date of a "completion of the investigation and study" shall be the date the three parties (US EPA, SCDHEC, and US DOE) provide final approval of the ESD for the unit, following the public comment period.

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APPENDIX A

OFASB AND LAOCB ALTERNATIVE COMPARISONS

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APPENDIX A OFASB AND LAOCB ALTERNATIVE COMPARISONS

A summary of the comparative analysis for remedial alternatives at the Old F-Area Seepage Basin (OFASB) and the L-Area Oil and Chemical Basin (LAOCB) are provided in Tables A-1 and A-2, respectively.

Table A-1. Comparative Analysis of Alternatives for OFASB (Soil/Vegetation)

Criterion	**OFASB Soil and Vegetation Alternatives**			
	Alternative 1 (No Action)	Alternative 2 (Capping)	Alternative 3A (In situ Grout to 2 ft/Incinerate Vegetation	Alternative 3B (In situ Grout to 2 ft/Dispose Vegetation)
Overall Protectiveness				
Human Health	Protective as long as institutional controls are maintained	Protective	Protective	Protective
Environment	Not Protective	Protective	Protective	Protective
Compliance with ARARs				
Chemical Specific	Meets UMTRA levels	Meets UMTRA levels	Meets UMTRA levels	Meets UMTRA levels
Location Specific	Not Applicable	Requires measures to prevent impact to neighboring wetlands	Requires measures to prevent impact to neighboring wetlands	Requires measures to prevent impact to neighboring wetlands
Action Specific	None	Requires NESHAPs air modeling/permitting	Requires NESHAPs air modeling/permitting	

Table A-1. Comparative Analysis of Alternatives for OFASB (Soil/Vegetation) (Cont)

Criterion	**OFASB Soil and Vegetation Alternatives**			
	Alternative 1 (No Action)	**Alternative 2 (Capping)**	**Alternative 3A (In situ Grout to 2 ft/Incinerate Vegetation**	**Alternative 3B (In situ Grout to 2 ft/Dispose Vegetation)**
Long-term Effectiveness and Permanence				
Magnitude of residual risks	OFASB waste unit would be a continual source of contamination to the environment; residual risks would be very high, particularly in the absence of institutional controls.	Much reduced over current conditions, but failure of the cap could pose risks to groundwater, onsite workers, and others unless further action is taken.	Residual risks would be much lower than Alternative 2, but failure of the cap could pose risks to groundwater, onsite workers, and others unless further action is taken; vegetative debris would not pose significant risks.	Same as Alternative 3A.
Adequacy of Controls	Existing institutional controls are effective for the protection of human health; but they cannot be guaranteed for as long as the contamination poses a risk to human health	Existing and supplemental institutional controls would be effective, but they cannot be guaranteed for as long as the contamination poses a risk to human health.	Existing ans supplemental institutional controls would be effective and grouting of the most contaminated soils would limit risk to groundwater should the cap ever fail.	Same as Alternative 3A.
Reduction of Toxicity, Mobility or Volume				
Treatment type	No Active treatment.	No active treatment	Stabilization/solidification of the most contaminated soils; incinerate vegetation.	Stabilization/solidification of the most contaminated soils; no treatment of vegetation.
Reduction of toxicity, mobility or volume	None through treatment.	Capping would effectively reduce contaminant mobility as long as cap integrity is maintained; not a permanent reduction in contaminant mobility.	Permanently reduces contaminant mobillity in the most threatening soils; reduce contaminant mobility and volume in vegetation.	Permanently reduce contaminant mobillity in the most threatening soils.

Table A-1. Comparative Analysis of Alternatives for OFASB (Soil/Vegetation) (Cont)

Criterion	OFASB Soil and Vegetation Alternatives			
	Alternative 1 (No Action)	**Alternative 2 (Capping)**	**Alternative 3A (In situ Grout to 2 ft/Incinerate Vegetation**	**Alternative 3B (In situ Grout to 2 ft/Dispose Vegetation)**
Short-term Effectiveness				
Risk to remedial workers	None; would involve no handling of contaminated media.	Minimal; volume of soils excavated: 130m^3 (4.5 x 103 ft^3; 1.6 x 10^3 yd^3); volume of vegetation processed 19 m^3 (660 ft^3; 24 yd^3).	Low; volume of soils excavated and processed: 130m^3 (4.5 x 103 ft^3; 1.6 x 10^3 yd^3); volume of vegetation processed 19 m^3 (660 ft^3; 24 yd^3).	Low; volume of soils excavated and processed: : 130m^3 (4.5 x 103 ft^3; 1.6 x 10^3 yd^3); volume of vegetation processed 19 m^3 (660 ft^3; 24 yd^3).
Risk to community	Negligible	Minimal	Very low; would involve transport of vegetation to CIF in E-Area.	Very low; would involve transport of vegetation to off unit disposal facility.
Construction Schedule	Immediately implementable	6 months	12 months	12 months
Implementability				
Potential Concerns	Potential for public concern in No Action is implemented.	None	Possibility in delay of CIF startup scheduled for Jan. 1996.	None
Relative implementability	Readily implementable	Readily implementable, but would require much more effort than No Action	Readily implementable after CIF startup; would require more effort than capping alone (Alt. 2).	Readily implementable; would require more effort than capping alone (alt. 2), but slightly less effort than Alt. 3A.
Cost				
Basis for O&M costs	30 years	30 years	30 years	30 years
Present worth capital costs	$0	$800,000	$1,6000,000	$1,300,000
Present worth O&M costs	$280,000	$500,000	$500,000	$500,000
Total present worth costs	$280,000	$1,300,000	$2,100,000	$1,800,000

Table A-1. Comparative Analysis of Alternatives for OFASB (Soil/Vegetation) (Cont)

Criterion	OFASB Soil and Vegetation Alternatives		
	Alternative 4A (Ex situ Grout to 2 ft/Incinerate Vegetation)	**Alternative 4B (Ex situ Grout to 2 ft/Dispose Vegetation)**	**Alternative 5 (Dispose Soil to 2 ft/Dispose Vegetation)**
Overall Protectiveness			
Human Health	Protective	Protective	Protective
Environment	Protective	Protective	Protective
Compliance with ARARs			
Chemical Specific	Meets UMTRA levels	Meets UMTRA levels	Meets UMTRA levels
Location Specific	Requires measures to prevent impact to neighboring wetlands	Requires measures to prevent impact to neighboring wetlands	Requires measures to prevent impact to neighboring wetlands
Action Specific	Requires NESHAPs air modeling/permitting	Requires NESHAPs air modeling/permitting	Requires NESHAPs air modeling/permitting
Long-term Effectiveness and Permanence			
Magnitude of residual risks	Residual risks would be lower than Alternatives 4A/B since treatment effectiveness would be confirmed; vegetative debris would not pose significant risks.	Same as Alternative 4A.	An estimated 53% of known Cs-137 and 97% of mercury in contaminated soil would be permanently removed; remaining Cs-137 and mercury would remain untreated and beneath cap.
Adequacy of Controls	Existing and supplemental institutional controls would be effective; risk to groundwater would be very low should the cap ever fail.	Same as Alternative 4A.	Existing and supplemental institutional controls would be effective; removal of the most contaminated soils would limit risk to groundwater should the cap ever fail.

Table A-1. Comparative Analysis of Alternatives for OFASB (Soil/Vegetation) (Cont)

Criterion	**OFASB Soil and Vegetation Alternatives**		
	Alternative 4A (Ex situ Grout to 2 ft/Incinerate Vegetation)	**Alternative 4B (Ex situ Grout to 2 ft/Dispose Vegetation)**	**Alternative 5 (Dispose Soil to 2 ft/Dispose Vegetation)**
Reduction of Toxicity, Mobility or Volume			
Treatment Type	Stabilization/solidification of all contaminated soils required to protect groundwater; incinerate vegetation.	Stabilization/solidification of all contaminated soils required to protect groundwater; disposal of vegetation.	Incinerate vegetation.
Reduction of toxicity, mobility or volume	Permanently reduce contaminant mobillity in contaminated soils requiring treatment; reduce contaminant mobility and volume in vegetation.	Permanently reduce contaminant mobility in contaminated soils requiring treatment.	Permanently reduce vegetative contamination mobility and volume.
Short-term Effectiveness			
Risk to remedial workers	Minimal; volume of soils excavated: 130 m^3 (4.5 x 10^3 ft^3; 1.6 x 10^3 yd^3); volume of vegetation processed 19 m^3 (660 ft^3; 24 yd^3).	Same as Alternative 4A.	High; volume of soils excavated: 3.6 x 10^3 m^3 (1.3 x 10^5 ft^3; 4.7 x 10^3 yd^3).
Risk to community	Very low; would involve transport of vegetation to CIF in E Area.	Very low; would involve transport of vegetation to Burial Grounds Debris Trenches in E Area.	Significant; assuming highway transport, Alt. 7A would involve approximately 313 round trips from SRS to Utah totaling 1.25 x 10^6 mi).
Construction Schedule	<12 months	<12 months	8 months

Table A-1. Comparative Analysis of Alternatives for OFASB (Soil/Vegetation) (Cont)

Criterion	OFASB Soil and Vegetation Alternatives		
	Alternative 4A (Ex situ Grout to 2 ft/Incinerate Vegetation)	**Alternative 4B (Ex situ Grout to 2 ft/Dispose Vegetation)**	**Alternative 5 (Dispose Soil to 2 ft/Dispose Vegetation)**
Implementability			
Potential concerns	Possibility in delay of CIF startup scheduled for January 1996; need for specialized grouting equipment.	Need for some specialized grouting equipment.	Possibility in delay of CIF startup scheduled for January 1996; potential for public opposition due to waste transport concerns.
Relative implementability	Implementable after CIF startup; would require much more than effort than grouting under Alternatives 3A/3B.	Implementable; would require slightly less effort than Alt. 4A for vegetation.	Readily implementable after CIF startup; would require a little more effort than ex situ grouting under 4A/4B.
Cost			
Basis for O&M costs	30 years	30 years	30 years
Present worth capital costs	$1,800,000	$1,400,000	$8,500,000
Present worth O&M costs	$500,000	$500,000	$500,000
Total present worth costs	$2,300,000	$1,900,000	$9,000,000

Table A-2. Comparative Analysis of Soil/Sediment Alternatives LAOCB

Criterion	LAOCB Soil Remedial Alternatives					
	Alternative S-1 No Action	Alternative S-2 Capping	Alternative S-3 Slurry Cut-Off Wall & Capping	Alternative S-4 In situ S/S & Capping	Alternative S-5 Ex situ S/S & Capping	Alternative S-6 Disposal at the Nevada Test Site
Overall Protectiveness						
Human Health	Protective as long as institutional controls are maintained	Protective	Protective	Protective	Protective	Protective
Environment	Protective as long as clay layer beneath Basin restricts migration	Protective	Protective	Protective	Protective	Protective
Compliance with ARARs						
Chemical-specific	Meets TSCA/UMTRCA levels; would not meet 40 CFR 191 or DOE Order 5400.5 (TBC) under hypothetical future conditions	Meets TSCA/UMTRCA levels; Complies with 40 CFR 191 and DOE Order 5400.5 (TBC)	Meets TSCA/UMTRCA levels; Complies with 40 CFR 191 and DOE Order 5400.5 (TBC)	Meets TSCA/UMTRCA levels; Complies with 40 CFR 191 and DOE Order 5400.5 (TBC)	Meets TSCA/UMTRCA levels; Complies with 40 CFR 191 and DOE Order 5400.5 (TBC)	Meets TSCA/UMTRCA levels; Complies with 40 CFR 191 and DOE Order 5400.5 (TBC)
Location-specific	Not Applicable	None	None	None	None	None
Action-specific	None	Requires NESHAPs air modeling & permitting; RCRA cap performance standards; erosion control plan; OSHA worker health & safety plan	Requires NESHAPs air modeling & permitting; RCRA cap performance standards; erosion control plan; OSHA worker health & safety plan	Requires NESHAPs air modeling & permitting; RCRA cap performance standards erosion; erosion control plan; OSHA worker health & safety plan	Requires NESHAPs air modeling & permitting; RCRA cap performance standards; erosion control plan; OSHA worker health & safety plan	Requires NESHAPs air modeling & permitting; RCRA cap performance standards; erosion control plan; OSHA worker health & safety plan

Table A-2. Comparative Analysis of Soil/Sediment Alternatives LAOCB (Cont)

Criterion	LAOCB Soil Remedial Alternatives					
	Alternative S-1 No action	Alternative S-2 Capping	Alternative S-3 Slurry Cut-off Wall & Capping	Alternative S-4 In situ S/S & Capping	Alternative S-5 Ex situ S/S & Capping	Alternative S-6 Disposal at the Nevada Test Site
Long-Term Effectiveness and Permanence						
Magnitude of residual risks	Residual risk could be high, particularly in the absence of institutional controls; clay layer beneath Basin could retard impact to groundwater	Much reduced over current conditions; capping and clay layer would retard migration of COCs	Residual risks would be lower than Alternative 2, total encapsulation of COCs.	Residual risk lower than Alternatives 2 and 3 due to grouting of the contaminants (protection of the environment)	Residential risk would be the same as Alternative 4	Residual risk would be minimal; contaminated soils would be permanently removed
Adequacy of controls	Existing institutional controls are effective for the protection of human health, but cannot be guaranteed; adequacy of the clay layer has proven effective, but can not be verified	Existing and supplemental institutional controls would be effective; cap and the clay layer beneath the Basin would retard migration of COCs	Existing and institutional controls would be effective; slurry wall, cap and the clay layer beneath the Basin would retard migration of COCs	Existing and supplemental institutional controls would be effective and grouting of the contaminated soils would further limit risk to the environment	Existing and supplemental institutional controls would be effective and grouting of the contaminated soils would further limit risk to the environment	No controls required; could be released for unrestricted land use

Table A-2. Comparative Analysis of Soil/Sediment Alternatives LAOCB (Cont)

Criterion	LAOCB Soil Remedial Alternatives					
	Alternative S-1 No action	Alternative S-2 Capping	Alternative S-3 Slurry Cut-off Wall & Capping	Alternative S-4 In situ S/S & Capping	Alternative S-5 Ex situ S/S & Capping	Alternative S-6 Disposal at the Nevada Test Site
Reduction of Toxicity, Mobility or Volume						
Treatment type	No active treatment	No active treatment	No active treatment	Stabilization/ solidification on the contaminated soil	Stabilization/ solidification of the contaminated soil	None
Reduction of toxicity, mobility or volume	None through treatment	Capping and the clay layer beneath the Basin would effectively reduce contaminant mobility as long as cap integrity is maintained; not a permanent reduction in contaminant mobility	Slurry wall, capping, and the clay layer beneath the Basin would effectively reduce contaminant mobility as long as cap integrity is maintained; not a permanent reduction in contaminant mobility	Permanently reduced contaminant mobility in the soils	Permanently reduce contaminant mobility in the soils	Contaminated soils removed, and relocated
Short-Term Effectiveness						
Risk to remedial workers	None; would involve no handling of contaminated media	Minimal	Minimal	Low	Medium; volume of soils excavated: 760 m^3 (27,000 ft^3, 1,000 yd^3)	Medium to high; volume of soils excavated and transported: 760 m^3 (27,000 ft^3, 1,000 yd^3)
Risk to community	Negligible	Minimal	Minimal	Minimal	Minimal	Medium; would involve transport of soils to the NTS
Construction schedule	Immediately implementable	3 months	6 months	12 months	15 months	3 months

Table A-2. Comparative Analysis of Soil/Sediment Alternatives LAOCB (Cont)

Criterion	LAOCB Soil Remedial Alternatives					
	Alternative S-1 No action	Alternative S-2 Capping	Alternative S-3 Slurry Cut-off Wall & Capping	Alternative S-4 In situ S/S & Capping	Alternative S-5 Ex situ S/S & Capping	Alternative S-6 Disposal at the Nevada Test Site
Implementability						
Potential concerns	Potential for public concern of no action is implemented	Potential for public concern since no treatment is performed	Potential for public concern since no treatment is performed	None	Medium; would require pre-excavation treatment for waste handling purposes	High; would involve transport of soils outside SRS boundaries; would require pre- & post-excavation treatment for waste handling & packaging purposes
Relative implementability	Readily implementable	Readily inplementable, but would require much more effort than No Action	Readily implementable; would require more effort than capping alone (Alt 2)	Readily implementable; would require more effort than capping alone (Alt 2)	Implementable; however, waste handling may cause down time during remediation; also requires pre-excavation treatment	Implementable; however, waste handling may cause down time during remediation; also requires pre- & post-excavation treatment
Cost*						
Basis for O&M costs	30 years	30 years	30 years	30 years	30 years	Not applicable
Present worth capital costs	$0	$1,000,000	$3,000,000	$3,150,000	$3,940,000	$9,100,000
Present worth O&M costs	$280,000	$430,000	$430,000	$430,000	$430,000	$0
Total present worth costs	$280,000	$1,430,000	$3,430,000	$3,580,000	$4,370,000	$9,100,000

*Costs are developed for comparison purposes only and are not intended to forecast actual expenditures. S/S = Stabilization/Solidification

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APPENDIX B

TECHNICAL EVALUATION REPORT TEMPALTATE

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United States Department of Energy

Savannah River Site

Technical Evaluation of the Plug-in Remedy for use at the (*Insert Operable Unit Name)* Operable Unit Report (U)

WSRC-RP-99-XXX

Revision 0

(Insert Date)

Prepared By:

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF ACRONYMS

AOC	area of contamination
COCs	contaminants of concern
DNAPL	dense non-aqueous phase liquid
FFA	Federal Facility Agreement
MCLs	maximum contaminant levels
mrem/yr	millirem/year
OU	operable unit
RAOs	remedial action objectives
RBCs	risk-based concentrations
RGs	remedial goals
ROD	Record of Decision
SCDHEC	South Carolina Department of Health and Environmental Control
SRS	Savannah River Site
US DOE	United States Department of Energy
US EPA	United States Environmental Protection Agency
VOC	volatile organic compound

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1.0 INTRODUCTION

The Plug-in Record of Decision for In Situ Stabilization With a Low Permeability Soil Cover System for Radiological Contaminants in Soil (U), WSRC-RP-98-4099 (plug-in record of decision [ROD]) identifies in situ stabilization with a low permeability soil cover system as the preferred response action for radioactively contaminated source units that meet specific criteria, such as reactor seepage basins. The remedy includes the use of institutional controls and allows for consolidation when appropriate. This conclusion was reached based on review of SRS decision precedents (i.e.,previous RODs) and supports the use of a plug-in approach. Because United States Department of Energy (US DOE), United States Environmental Protection Agency (US EPA), and South Carolina Department of Health and Environmental Control (SCDHEC) have agreed to apply the remedy at radioactively contaminated source units that meet the conditions defined in the plug-in ROD.

The purpose of this document is to demonstrate that the *(insert OU name)* meets the criteria specified in the plug-in ROD. This document will also specifically describe how the remedy will be applied to *(insert OU name).* When approval of this technical evaluation report and an associated ESD is received from the US EPA and the SCDHEC the OU shall adopt the plug-in remedy, in situ stabilization with a low permeability soil cover system, as described in the plug-in ROD.

The remedy selected in the Plug-in ROD is designed to meet the following remedial action objectives (RAOs):

1) Prevent human exposure to highly contaminated basin soils (PTSM) by performing stabilization treatment to the extent practicable, and filling the basins. Reduce risks to the future worker from surface soils (0 to 0.3 m [0-1 foot]) outside the basin by establishing remedial goals (RGs) for, constituents of concern (COCs) at concentrations equivalent to

1×10^{-6} for carcinogens and a hazard quotient of 1 for non-carcinogens or background (where background levels of COCs exceed 1×10^{-6}).

2) Prevent the release of COCs in soil to groundwater beneath the unit above maximum contaminant levels (MCLs) or risk-based concentrations (RBCs) if MCLs are not available. The soil RGs are back calculated based on these values.

3) Protect the ecological receptors indigenous to the area by preventing or limiting contact with contaminated soils and pipelines, and preventing the plant and animals from bringing contaminants up towards the surface.

2.0 SCOPE AND ROLE OF THE *(INSERT OU NAME)* OU

Releases of radioactive contaminants at non-permitted waste units are subject only to Comprehensive Environmental Response Compensation and Liability Act (CERCLA) requirements. *(Insert the OU Name)* is identified in the SRS Federal Facility Agreement (FFA) and as such is required to be investigated to determine if the OU contains unacceptable risks and if remedial actions are warranted. Sampling has been completed as part of the *(Fill in appropriate administrative document).*

(Insert the name of the OU) OU consists of *(describe applicable media).* The source term at this waste unit accounts for a significant portion of the current risk to human health and the environment and may present a potential long-term threat to groundwater. The source term area of contamination (AOC) consists of *(describe appropriate basins, pipelines, soil areas, etc.).*

The remedy selected in the plug-in ROD is designed to significantly reduce the risk from the source term to acceptable levels for future nonresidential land use. It is also designed to prevent migration of soil contaminants to the groundwater in quantities that exceed target groundwater concentrations MCLs or RBCs.

The plug-in ROD designates the final remedial decision for the source term at the *(Insert the OU Name)* OU. However, because the plug-in ROD does not include all media (target applicable media such as groundwater), this decision is considered an interim ROD for the OU. A final OU ROD will be required to complete remedial decision-making on *(Insert the OU Name)* OU. (modify if groundwater is being addressed as part of a separate OU)

The final ROD for this OU will be completed according to the schedule proposed in the *(insert name of the primary document that the decision document was submitted with).*

3.0 BACKGROUND OF THE *(INSERT OU NAME)* OU

This section would include a history of the OU and any other pertinent background data and reference to Figure 1 and Figure 2.

4.0 PLUG-IN CRITERIA

The plug-in criteria are used to evaluate whether the waste units match the conditions that the plug-in remedy has been designed to address. Therefore, the plug-in criteria have been developed based on the conditions for which in situ stabilization with a low permeability soil cover system is the preferred response action.

The plug-in criteria have been formulated as four key questions that the decision-makers (US DOE, US EPA and SCDHEC) must consider when evaluating a unit for a plug-in. If any of the answers to the indicated four questions is “No,” then the Plug-in ROD is not appropriate and an alternate administrative pathway will be used.

The four key questions are:

1. Is the operable unit radiologically contaminated?

2. Is the operable unit in a current industrial use area (with buffer) adjacent to an existing nuclear facility (as defined in Figure 2)?

3. Does the unit contain PTSM? For the purposes of the plug-in remedy only, PTSM is defined as soil which poses a radiological risk (using baseline risk assessment exposure assumptions) to a future industrial worker equal to or greater than 1×10^{-3}.

4. Is PTSM not in direct contact with surface water or groundwater or directly adjacent to surface water?

Figure 1. Map of SRS Showing the Location of (Insert OU Name) Relative to the Industrial Use Area (With Buffer)

Insert Map of SRS with the Industrial Use Areas (With Buffer) indicated.

Figure 2. *(Insert OU name)* with Current Industrial Use Area and Institutional Control Area)

Insert map of OU.

Figure 3 is a flowchart that indicates the plug-in logic and mechanics for determining if an OU meets the plug-in criteria.

4.1 Is the Unit Radiologically Contaminated?

This section should summarize the radiological data for the OU and end with a determination whether the OU is radiologically contaminated and thus meets plug-in criteria #1

4.2 Is the Unit Located in a Current Industrial Use Area (With Buffer) Adjacent to a Nuclear Facility?

This section should discuss the location of the OU and reference figures showing that it is located within the current industrial use (with buffer) area and thus meets plug-in criteria #2.

4.3 Does the OU Contain PTSM?

This section should determine whether the risk to a future industrial worker exceeds 1 x 10^{-3} (see Plug-in ROD, Appendix C) and thus meets plug-in criteria #3.

4.4 Is PTSM Not in Direct Contact with Surface Water or Groundwater or Immediately Adjacent to Surface Water?

This section should discuss the specific hydrology of the OU, depth to the water table, and any groundwater contamination in the vicinity of the unit. The fate and transport of tritium discharged to the basin should also be discussed. This section should also evaluate the efficacy of the remedy if vadose zone soils are contaminated to the depth of the water table. The final conclusion should state whether plug-in criteria #4 is met.

Figure 3. Plug-in Logic and Mechanics

Insert Figure 5 from the Proposed Plan

5.0 IN SITU STABILIZATION WITH A LOW PERMEABILITY SOIL COVER SYSTEM APPLIED TO (INSERT OU NAME)

This section should describe how the five remedy aspects (institutional controls, in situ stabilization, soil cover system, soils consolidation, and pipeline grouting) would be applied at this OU, and will meet each of the relevant RAOs.

5.1 Institutional Controls

Reference Figure 2 and explain how the OU is located within the current industrial use (with buffer) area.

5.2 Soils Consolidation

Discuss the location, volume, and depth of any surficial soil outside the basin or soil contaminated from pipeline leaks that will be consolidated into the primary discharge basin, explaining how it was determined that this soil needed to be consolidated (characterization data compared to soil RGs developed for soils outside the basin based on industrial worker exposure, a fate and transport model calculation to protect groundwater, and if PTSM criteria is exceeded). The calculations based on Appendix D of the Plug-in ROD are shown in Appendix A.

5.3 In Situ Stabilization

Describe the area and depth of soil to be in situ stabilized. Discussion should include why jet grouting or soil mixing was selected, why the depth was selected, etc. A discussion of any material that will be consolidated before stabilization should also be included.

5.4 Soil Cover

The cover system will be designed with a permeability low enough to prevent migration of the radionuclides to the groundwater for 1,000 years at levels that will exceed MCLs. Modeling based on Appendix D of the Plug-in ROD will be conducted to determine if a reduced infiltration rate based on a soil cover system with a hydraulic conductivity of 10^{-5} will be adequate for the basin(s). The calculations based on Appendix D of the Plug-in ROD are shown in Appendix A. This section will also describe how the soil cover would be applied. If a soil cover system with a hydraulic conductivity of less than 1×10^{-5} cm/s is required based on the modeling, the components of this cover system would be described. Figures showing the areal coverage and cross-sectional view of the cover system should be provided.

5.5 Pipelines

Discuss the location and length of the pipeline to be grouted. Include a discussion of any of details of the pipe that would likely interest the regulators or public such as diameter, length, material of construction, location of leaks (if any), depth of pipeline, etc. Include drawings or sketches, if available.

6.0 SUMMARY/CONCLUSIONS

The technical evaluation of (insert OU name) against the four plug-in criteria demonstrates that (Insert OU name) does/does not plug-in to the Plug-in ROD, and thus the remedy is specified in Section 5.0 should/should not be applied to (insert OU name).

The application of the remedy as described in Section 5.0 will meet the RAOs established in the Plug-in ROD and presented in Section 1.0.

7.0 REFERENCES

APPENDIX A
***(1nsert Operable Unit Name)* Fate and Transport Calculations.**

APPENDIX C

PRINCIPAL THREAT SOURCE MATERIAL CALCULATION

APPENDIX C PRINCIPAL THREAT SOURCE MATERIAL CALCULATION

This appendix provides the methodology for determining whether soil contamination associated with a candidate OU can be classified as principal threat source material (PTSM). For the purposes of this plug-in remedy only, PTSM is defined as soil which poses a radiological risk (using baseline risk assessment exposure assumptions) to a future industrial worker equal to or greater than 1 x 10^{-1}. This plug-in ROD is biased towards active remediation and treatment of units that are known to present a significant threat to human health and the environment. Thus, PTSM must be present (carcinogenic risks must exceed 1 X 10^{-3}) before this plug-in remedy is considered for a candidate OU.

Accordingly, a detailed evaluation of unit risks (e.g., baseline risk assessment) will not be performed for each plug-in candidate unit. Instead, a table of risk-based treatment threshold values (TTVs) (Table C-2) will be used to identify whether PTSM is present, based on the presence of radionuclides in soil contributing to a risk greater than 10^{-3} . These screening values will be based on the external and ingestion exposure pathways to soil for radionuclides as they account for nearly 100 percent of the risk related to radionuclides.

Exposure assumptions will be based on default assumptions used as part of the future worker scenario, and are presented on Table C-1. Ingestion and external radiation slope factors needed for the derivation of TTVs for radionuclides were taken from the Health Effects Assessment Summary Tables (HEAST) (US EPA 1995a). If decay products are in secular equilibrium with the parent isotope, as given by the "+D" listings in the Health Effects Assessment Summary Tables (HEAST) (US EPA 1995a), contributions for the daughter products are incorporated into the slope factor for the parent isotope. The slope factors for all potential radionuclides measured in soils are presented on Table C-2. This table also presents half-lives for each radionuclide.

The following equations were used to calculate the treatment threshold soil concentrations for radionuclides.

$$TTV_{Rad} = TR / (EF \times ED)x((IRo \times SFo) + (DE \times [1\text{-}Se] \times CF \times SFe))$$

where:

TTV_{Rad}	=	treatment threshold value for radionuclides (pCi/soil)
TR	=	target risk (1×10^{-3}) for deriving cancer-based TTV for radiological constituents (unitless)
EF	=	exposure frequency --(days/year)
ED	=	exposure duration --(yr)
IRo	=	oral intake rate (g soil)
SFo	=	oral slope factor (risk/pCi)
DE	=	direct exposure factor for external radiation pathway --0.33 (8hrs/24/hrs)
Se	=	shielding factor—0.2
CF	=	Conversion factor 2.74×10^{-3} yrs/day
SFe	=	external exposure slope factor (risk/year per pCi/g soil)

The back-calculated TTVs are presented in Table C-2. The surficial basin bottom (0- to1-foot) radionuclide concentrations (reasonable maximum exposure concentration) for an individual discharge basin can be directly compared to the values in this table. If the OU soil concentrations for an individual radionuclide does not exceed its respective TTV, an additive calculation can be performed to determine if the additive risk from all radionuclides and non-radionuclides exceeds the $1 \text{ X } 10^{-3}$ risk threshold.

References

US EPA, 1991b. *Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors*. OSWER Directive 9285.6-03, Office of Emergency and Remedial Response. US Environmental Protection Agency, Washington, DC.

US EPA. 1991c. *Risk Assessment Guidance for Superfund: Volume 1 - Human Health Evaluation Manual (Part B), Development of Risk-Based Preliminary Remediation Goals*. Office of Emergency Response. US Environmental Protection Agency, Washington, DC.

US EPA. 1995a. *Health Effects Assessment Summary Tables: FY-1995 Supplement*. EPA/540/R-95/142. Office of Solid Waste and Emergency Response. US Environmental Protection Agency, Washington, DC.

US EPA. 1995b. *Supplemental Guidance to RAGS: Region 4 Bulletins (Data Collection and Evaluation, Toxicity Assessment, Exposure Assessment, Risk Characterization, Development of Risk-Based Remedial Options).* Interim Draft, Office of Technical Services, Atlanta, GA.

Table C-1. Exposure Factors for the Derivation of TTVs

Pathway	Assumption	Unit	Exposure Factor	
General				
	Exposure Duration	years	25	a
	Exposure Frequency	day/year	250	a
Soil Ingestion				
	Ingestion Rate	g soil/day	0.050	b
	Conversion Factor-Radionuclides	year/day	2.74 E-03	
External Radiation				
	Gamma Shielding Factor	unitless	0.2	c
	Gamma Exposure Time Factor	unitless	0.33	

[a] US EPA 1995b

[b] US EPA 1991b

[c] US EPA 1991c

Table C-2 Half-lives, Slope Factors, and Treatment Threshold Values for Radionuclides

Isotope		Half-life [a]	Slope Factors Ingestion (Risk/pCi) [a]	Slope Factors External (Risk/yr per pCi/g soil) [a]	Target Cancer Risk	TTV (pCi/g)
Actinium-228	c	6.13 h	1.62E-12	3.28E-06		
Americium-241		432 y	3.28E-10	4.59E-09	1.0E-03	8.11E+03
Americium-243	+D	7380y	3.31E-10	2.66E-07	1.0E-03	7.66E+02
Carbon-14		5730y	1.03E-12	0.00E+00	1.0E-03	3.11E+06
Cesium-137	+D	30.2 y	3.16E-11	2.09E-06	1.0E-03	1.06E+02
Cobalt-60		5.27 y	1.89E-11	9.76E-06	1.0E-03	2.27E+01
Curium-243/244	b		2.51E-10	1.71E-07	1.0E-03	1.17E+03
Curium-243		28.5 y	2.51E-10	1.71E-07	1.0E-03	1.17E+03
Curium-244		18.1 y	2.11E-10	2.07E-11	1.0E-03	1.51E+04
Curium-245/246	b		3.35E-10	5.51E-08	1.0E-03	2.83E+03
Curium-245		8,500 y	3.35E-10	5.51E-08	1.0E-03	2.83E+03
Curium-246		4,750 y	3.32E-10	1.81E-11	1.0E-03	9.63E+03
Europium-152		13.3y	5.73E-12	4.08E-06	1.0E-03	5.42E+01
Europium-154		8.8 y	9.37E-12	4.65E-06	1.0E-03	4.76E+01
Iodine-129		1.57E7y	1.84E-10	2.69E-09	1.0E-03	1.44E+04
Lead-212	c	10.6 h	1.80E-11	3.00E-07		
Neptunium-237	+D	2.14E+06y	3.00E-10	4.62E-07	1.0E-03	4.58E+02
Neptunium-239	c	2.355d	4.27E-12	2.42E-07		
Nickel-63		100 y	5.50E-13	0.00E+00	1.0E-03	5.82E+06
Plutonium-238		87.8 y	2.95E-10	1.94E-11	1.0E-03	1.08E+04
Plutonium-239/240	b		3.16E-10	1.87E-11	1.0E-03	1.01E+04
Plutonium-239		24,100 y	3.16E-10	1.26E-11	1.0E-03	1.01E+04
Plutonium-240		6,570 y	3.15E-10	1.87E-11	1.0E-03	1.02E+04
Promethium-147		2.62 y	1.41E-12	6.35E-12	1.0E-03	2.13E-06
Radium-226	+D	1600y	2.96E-10	6.74E-06	1.0E-03	3.27E_01
Radium-228	+D	5.76y	2.48E-10	3.28E-06	1.0E-03	6.71E+01
Sodium-22		2.60 y	8.02E-12	8.18E-06	1.0E-03	2.70E+01
Strontium-90	+D	28.6 y	5.59E-11	0.00E+00	1.0E-03	5.72E+04
Technetium-99		2.13E+05 y	1.40E-12	6.19E-13	1.0E-03	2.27E+06
Thorium-228	+D	1.91 y	2.31E-10	6.20E-06	1.0E-03	3.56E+01
Thorium-230		7.7E+04 y	3.75E-11	4.40E-11	1.0E-03	8.39E+04
Thorium-232		1.41E+10 y	3.28E-11	1.97E-11	1.0E-03	9.67E+04
Uranium-233/234	b		4.48E-11	3.52E-11	1.0E-03	7.06E+04
Uranium-233		1.59E+05 y	4.48E-11	3.52E-11	1.0E-03	7.06E+04
Uranium-234		2.45E+05 y	4.44E-11	2.14E-11	1.0E-03	7.16E+04
Uranium-235		7.04E8y	4.70E-11	2.65E-07	1.0E-03	8.25E+02
Uranium-238	+D	4.47E+09 y	6.20E-11	5.25E-08	1.0E-03	3.90E+03

[a] Cancer slope factor and nuclear half-lives are provided in Health Effects Assessment *Summary Tables (FY-1995)* (EPA,1995a)
[B] Where there are dual designations for cancer slope factors (e.g., curium-243/244), the Most restrictive value for each exposure route was used in the calculation Of the TTV.
[C]TTV associated with the parent radionuclide
D+ Includes short-lived daughters (half-lives less than or equal to 6 months).

APPENDIX D

SOIL LEACHABILITY REMEDIAL GOALS

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APPENDIX D SOIL LEACHABILITY REMEDIAL GOALS

1.0 APPLICATION

The methodology provided in this appendix can be used to (1) determine whether contaminated soils outside of the area to be in-situ stabilized and soil covered pose a leachability threat to groundwater, and (2) determine if the 1×10^{-5} cm/s hydraulic conductivity soil cover system is adequate to prevent groundwater impact from contaminated soils that are present in the basins.

The second remedial action objective specifically requires that the groundwater be protected to meet MCLs or RBCs if MCLs are not available. Based on these target groundwater remedial goals, acceptable soil levels can be back calculated. Calculation of these soil leachability remedial goals (SLRG) will be conducted on a unit-specific basis, since the SLRGs are dependent upon unit-specific variables such as the thickness of the source contamination, the depth to the water table, and the groundwater velocity.

For radionuclides, the target groundwater remedial goals are set to existing and proposed standards. The 4 mrem/yr standard is used for beta particle and photon (gamma) emitters, except as specified for tritium and strontium-90. Based on this dose standard, an equivalent water concentration (activity) is calculated as required by 40 CFR 141.16. For alpha emitters, the existing final standard for radium-226 and radium-228 (5 pCi/L), the proposed standard for total uranium (20 ug/L), and the existing final standard for other alpha emitters (15 pCi/L) are used. For non-radionuclide contaminants of concern (COC) with no available MCL, the RBC is established based on the incremental excess cancer risk of 1×10^{-6} or a hazard quotient of 1.0 for non-carcinogens.

The approaches for back-calculating the acceptable soil limits based on these target remedial goals in groundwater are consistent with US EPA (1996a), considering biological and physical half-lives, and mass limit values. A time limit of 1,000 years is also used to determine those constituents that pose a future leachability risk, consistent with the approved SRS approach used for residual source contamination. This time frame is also consistent with the standard for effectiveness in considering control of residual radioactive material from inactive uranium processing sites (10 CFR 192.02).

If a contaminant concentration exceeds its SLRG, migration to groundwater is a concern, and a low-permeability soil cover system should be applied.

2.0 COMPARISON OF UNIT-SPECIFIC SOIL DATA TO SOIL LEACHABILITY REMEDIATION GOALS

Soils data for unit-specific constituents (USC) are compared to unit-specific SLRG and mass limit soil leachibility remedial goals (MLSLRG) calculated by a unit-specific model in accordance with US EPA guidance (US EPA 1996a,b). The SLRG is a conservative soil contaminant concentration below which there may be negligible concern, provided that the conditions at the unit match those established for use in calculating the SLRG. The SLRG, however, may violate mass balance considerations due to the assumption of an infinite source (US EPA 1996a). The MLSLRG provides an equally protective soil screening level that assumes that the entire mass of contamination leaches over the 70-year exposure duration (US EPA 1996a). The MLSLRG is established such that the mass of contaminant leached into groundwater cannot exceed the total mass of contaminant present in the soils.

The nature of the input data and the analytical model assumptions are such that the resulting estimates of groundwater concentrations are conservative. The following sections discuss the input data and analytical model assumptions, and the results of the modeling.

2.1 Input Data and Assumptions

The soil leachability estimate can be performed using analytical equations programmed into an Excel® spreadsheet. The major assumptions made in the soil leachability analysis are:

- Infinite and uniform source of contaminants
- One-dimensional, steady flow with uniform average soil properties
- Reversible, equilibrium, linear soil-water distribution of contaminants
- Biological decay is aerobic and is described by a first-order rate constant
- No volatilization of contaminants
- Dilution factor (US EPA 1996a) calculation method is reasonable
- The pH of the soil water is approximately 5

A uniform and infinite source of contaminants is conservatively assumed to simplify leaching estimates.

Steady one-dimensional flow in the vadose zone is assumed to represent average flow over the period of interest. Dispersion is not incorporated into the vadose zone estimate because it does not significantly affect the maximum groundwater concentration or the time that it occurs (assuming that the contamination is not a "point source").

Reversible, equilibrium adsorption of contaminants is incorporated through a distribution coefficient (K_d).

First-order decay of contaminants is incorporated by utilizing published half-lives. For radionuclides, the half-life is due to radioactive decay, and for organic contaminants the half-life is due to biological reaction. Parent radionuclide USCs with half-lives less than 1 year are not included in the leachability analysis if the subunit has been inactive for 10 years or longer. Metals are assumed not to undergo any non-adsorptive-type reactions (decay), which is reasonable and slightly conservative.

Volatilization of potentially volatile organic compounds is not incorporated into the estimate because it is expected to be minimal and because not incorporating volatilization is slightly more conservative.

The final element of the CSM is a hypothetical water well installed at the boundary of the unit. This well is the target for which MCLs apply.

Constituent-specific information, such as biological half-lives (for the organic contaminants), radiological half-lives (for the radioactive contaminants), and distribution coefficients are required for the soil leachability model. Values of biological half-lives chosen for this calculation are those reported for soil (where aerobic biological half-lives are typically two to 20 times less than those in groundwater because oxygen is more readily available in soil).

The average concentration of each USC across the contaminated zone is used. This is consistent with the conceptual model for seepage basins that received wastewater discharge. Hot spots may be modeled if consistent with the characterization data.

2.2 Method and Calculations

Based on previously presented assumptions, the equation that describes the SLRG in a sub-unit is given by:

$$SLRG = \frac{C_w * K_d * DF}{EXP(-0.693 * T_{max}/t_{1/2})}$$

where:

SLRG = soil leachability remedial goal (mg/kg or pCi/g)

C_w = target groundwater concentration (MCL or RBC in µg/L, or pCi/L for radionuclides)

Kd = distribution coefficient (L/kg, L/g for radionuclides)

T_{max} = time (years) that the maximum soil water concentration occurs at the water table surface

$t_{1/2}$ = environmental or radiological half-life of the constituent (years)

DF = groundwater dilution factor (unitless)

T_{max} is estimated by dividing the distance from the source to the top of the water table surface (L_v) by the retarded soil water velocity. Using a uniform source concentration over the thickness of the soil layer modeled also results in the maximum groundwater concentration being achieved at T_{max}. That is,

$$T_{max} = \frac{L_v * R}{V_s}$$

where:

L_v = distance from the source to the water table (ft) determined for each USC by measuring from the bottom of the deepest sampling interval in which the USC was detected to the top of the water table

V_s = soil water velocity in the vadose zone (ft/year)

R = retardation coefficient (unitless)

V_s is calculated based on the recharge rate (ft/yr), effective porosity (dimensionless), and moisture content at a specific unit (US EPA 1996b) as follows:

$$V_s = \frac{I * n_t}{\Theta * n_e}$$

where:

I = recharge rate (ft/year)

n_e = effective porosity (unitless)

n_t = total porosity (unitless)

g = fraction moisture content (unitless) and:

$$\Theta = n_t \left(\frac{I}{K} \right)^m$$

where:

K = hydraulic conductivity (ft/year)

m = 1/(2b + 3), where b is empirically based on the soil type (unitless)

The recharge (infiltration) rate of 1.25 ft/year, total porosity of 0.5, and the effective porosity of 0.2 is based on Looney et al. (1987) and represents the lower, more conservative range of effective porosities typically used.

The retardation coefficient is calculated for each USC as:

$R = 1 + (K_d * {}_{Pb}/n_T)$

where:

K_d = distribution coefficient (L/kg)

P_b = bulk soil density (kg/L)

n_T = total porosity (unitless)

The bulk soil density of 1.6 kg/L and the total porosity of 0.5 are based on Looney et al. (1987). The hydrogeologic parameters required for the model are presented in Table D-1.

For a given substance, distribution coefficients can vary widely depending upon soil chemistry (cation exchange capacity, amount of organic carbon, etc.) and soil water (vadose zone) chemistry (pH, total dissolved ions, etc.). The value selected for the distribution coefficient significantly affects the estimated groundwater concentrations in the saturated zone and thus the SLRG. Initial conservative, yet reasonable, estimates of distribution coefficients, the resultant retardation coefficients, and biological/radiological half-lives of the USCs are provided in Tables D-2 through D-6.

The distribution coefficient (K_d) of an organic compound is related to the organic-carbon partition coefficient (K_{oc}) by:

$K_d = f_{oc} K_{oc}$

where:

f_{oc} is the soil organic-carbon content as volume fraction

A default f_{oc} of 0.002 (US EPA 1996a) is used for the site. A unit-specific value should be substituted if the organic content of the soil at the unit is known. Constituent-specific K_{oc} values were obtained from the literature, some of which were calculated using empirical formulas relating the octanol-water partitioning coefficient (K_{ow}) to the K_{oc}.

It is important to recognize, with regard to distribution coefficients, that some "contaminants" such as iron affect adsorption and are controlled by solubility at a pH of 5 in oxidizing environments. Thus a K_d for iron is not appropriate. Many metals naturally occur at relatively high levels in the environment in soil, and the use of K_d may not be appropriate, since only the incremental contamination above background is available for leaching to groundwater in the time frame of interest.

The groundwater dilution factor for this analysis is calculated as described by US EPA (1996a):

DF = 1+(Ki*d/IL) (dimensionless)

where:

K = horizontal hydraulic conductivity (ft/year)

i = hydraulic gradient (length per unit length)

d = mixing zone depth (ft)

I = infiltration rate (ft/year)

L = length of source parallel to flow (ft)

The horizontal hydraulic conductivity, hydraulic gradient, and length of source parallel to flow are unit-specific parameters.

The mixing zone depth is calculated as follows (US EPA 1996a):

$d = (0.0112L^2)^{½} + d_a\{1 - \exp[(-LI)/(Kid_a)]\}$

where:

d_a = aquifer depth (ft)

The actual mixing zone depth used is the minimum of the calculated mixing zone depth (d) and the aquifer thickness (d_a) (i.e., to be physically realistic, the mixing zone cannot be greater than the aquifer thickness).

The dilution factor calculation is slightly conservative from an exposure viewpoint because it does not account for additional dilution that occurs when groundwater is pumped at a supply well. Additional dilution could occur at a pumped well for at least two reasons: (1) the assumed mixing depth would probably be different from the actual depth of the screen location of a water supply well, and (2) the capture zone of a supply well may intercept water from significant areas of uncontaminated aquifer, which also decreases the contaminant exposure concentration.

The MLSLRGs are calculated by:

$$MLSLRG = \frac{C_{gw} * DF * I * ED}{\rho_b * d_s}$$

where:

MLSLRG = unit-specific MLSLRG (mg/kg, pCi/g for radionuclides)

C_{gw} = target groundwater concentration, MCL, or health-based RBC

I = infiltration rate (1.42 ft/yr)

ED = US EPA default exposure duration (70 yr)

Pb = soil bulk density (1.6 kg/L, 1600 g/L for radionuclides)

d_s = vertical thickness of the contaminated zone, unit-specific

2.3 Results

Output tables will provide the SLRGs and MLSLRGs for all potential USCs upon input of unit-specific information for radionuclides, metals, VOCs, SVOCs, and pesticides/PCBs, respectively. The tables will also include the calculated retardation coefficient, time for the maximum concentration to occur, maximum groundwater concentration, and applicable MCL or RBC. Where the soil concentration of an individual constituent exceeds the greater of the SLRG or MLSLRG, that constituent is identified in the “analytes greater than MCL/RBC column.

The SLRGs presented are based on fairly conservative assumptions. The assumption that the source of a constituent is uniformly distributed to the depth of detection at an average concentration may be conservative and overestimates the distribution and mass of the constituent in the subsurface, where the constituents are only sporadically detected and not uniformly distributed. Alternatively, localized hot spots may not be adequately addressed by averaging, although contaminant concentrations in soils impacted by liquid effluent discharges are expected to be relatively uniform. The receptor well is conservatively placed at the edge of the source unit; therefore, the dilution that would occur when clean water is withdrawn at the receptor well is not incorporated. This effect becomes more important when the source of contamination is of small areal extent, such as for a pipeline leak. The leachability analysis assumes that the entire mass of a constituent is mobile when, for many naturally occurring metals and radionuclides, a large fraction is immobile (e.g., background concentrations of metals). The distribution coefficients that are utilized are predominantly for sand, when in reality the geology is a heterogeneous system of sand, silt, clay and organic matter. In general, silt, clay and organic matter are more likely to retard the movement of contaminants. This heterogeneous stratigraphy also impacts results in variable vertical hydraulic conductivity, which may significantly slow infiltration through the vadose zone, but was not accounted for in this calculation.

Based on these assumptions, many of which are conservative, it may be appropriate to conduct additional unit-specific modeling to more accurately calculate appropriate SLRGs. The modeling results should always be compared to empirical groundwater and soils data to the extent available in order to verify the model.

In order to determine if a 10^{-5} cm/s permeability soil cover will provide adequate protection of groundwater, the infiltration rate in the model can be reduced by 60 percent to mimic the reduced infiltration that will be achieved over native conditions through application of the soil cover. This 60 percent reduction in the infiltration rate was predicted by the HELP model, an EPA model used to determine infiltration reduction for various landfill design systems. The reduction infiltration is due to a combination of increased runoff due to the soil cover slope, evapotranspiration from the vegetative cover, and lower infiltration rates due to lower permeability of the soil cover as compared to native soils. If a constituent is identified in the "analytes greater than MCL/RBC column", a more rigorous cap should be considered.

3.0 DATA NEEDS

In order to calculate the unit-specific SLRGs, the following information will be required on an operable unit level:

- the horizontal hydraulic conductivity of the aquifer
- the hydraulic gradient
- the aquifer thickness
- if available, empirical groundwater contaminant concentration data (to verify the model)

The following information will be required for each basin or discrete contaminated area:

- average soil concentrations for the volume of soil impacted (hot spot averages may also be appropriate)
- the thickness of the contaminated soil zone
- the length of the source parallel to flow
- the depth from the bottom of the contaminated zone to the water table

4.0 REFERENCES

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US EPA, 1996b. Soil Screening Guidance: User’s Guide. EPA 540/R-96/018.

Table D-1. Hydrogeological Parameters for Soil Leachability Remedial Goal Calculations

PARAMETER		VALUE	DATA SOURCE
I	Recharge rate (ft/yr)	1.25	Looney et al. 1987
f_{oc}	fraction of organic carbon	0.002	US EPA 1996a
P_b	Bulk Soil Density (gm/cm^3)	1.6	Looney et al. 1987
n_T	Total Porosity	0.5	Looney et al. 1987
n_e	Effective Porosity	0.2	Looney et al. 1987
DF	Dilution Factor	TBD	WSRC 1997
d_s	Thickness of Source (ft)	TBD	WSRC 1997
d_a	Dept to Groundwater (ft)	TBD	WSRC 1997

TBD- to be determined

Table D-2. Input Parameters for Radionuclides

Radiological Analytes	koc (RAD) L/kg	Kd[10] (RAD) L/g	T1/2 (RAD) Years	Cs (RAD) pCi/g
Acitinium-228	NA	0.45	0.0007	
Americium-241	NA	0.1	432	
Americium-243	NA	0.1	7380	
Antimony-124	NA	4	0.165	
Antimony-125	NA	4	2.77	
Carbon-14	NA	0.002	5730	
Cesium-134	NA	0.5	2.06	
Cesium-137	NA	0.5	30.2	
Cobalt-57	NA	0.01	0.742	
Cobalt-60	NA	0.01	5.27	
Curium-242	NA	3.1	0.447	
Curium-243/244	NA	3.1	28.5	
Curium-245/246	NA	3.1	8,500	
Curium-247	NA	3.1	15,600,000	
Europium-152	NA	0.245	13.6	
Europium-154	NA	0.245	8.8	
Europium-155	NA	0.245	4.96	
Iodine-129	NA	0.0036	15,700,000	
Lead-212	NA	0.27	0.00012	
Manganese-54	NA	0.05	0.858	
Neptunium-237	NA	0.01	2,140,000	
Neptunium-239	NA	0.01	0.0065	
Nickel-63	NA	0.065	100	
Plutonium-238	NA	0.1	87.8	
Plutonium-239/240	NA	0.1	24100	
Potassium-40	NA	0.075	1,280,000.000	
Promethium-147	NA	0.24	2.62	
Radium-226	NA	0.1	1600	
Radium-228	NA	0.1	5.75	
Sodium-22	NA	0.1	2.6	
Strontium-90	NA	0.008	28.6	
Technitium-99	NA	0.0001	217,000	
Thorium-228	NA	0.1	1.91	
Thorium-230	NA	0.1	77,000	
Thorium-232	NA	0.1	14,100,000,000	
Uranium-233/234	NA	0.04	245,000	
Uranium-235	NA	0.04	704,000,000	
Uranium-238	NA	0.04	4,470,000,000	
Zinc-65	NA	0.062	0.668	
Zirconium-95	NA	0.6	0.175	

Table D-3.Input Parameters for Metals

Metal Analytes	KOC (Metal) L/Kg	Kd[10] (Metal) L/Kg	T1/2 (Metal) Years	Cs (Metal) mg/kg
Aluminum, total recoverable	NA	1500	Infinite	
Antimony,total recoverable	NA	400	Infinite	
Arsenic, total recoverable	NA	39	Infinite	
Barium, total recoverable	NA	41	Infinite	
Beryllium, total recoverable	NA	790	Infinite	
Cadmium, total recoverable	NA	75	Infinite	
Calcium, total recoverable	NA	No Kd available	Infinite	
Chromium, total recoverable	NA	1,800,000	Infinite	
Cobalt, total recoverable	NA	10	Infinite	
Copper, total recoverable	NA	25	Infinite	
Cyanide	NA	9.9	Infinite	
Iron, total recoverable	NA	220	Infinite	
Lead, total recoverable	NA	270	Infinite	
Magnesium, total recoverable	NA	No Kd available	Infinite	
Manganese, total recoverable	NA	50	Infinite	
Mercury, total recoverable	NA	52	Infinite	
Nickel, total recoverable	NA	65	Infinite	
Potassium, total recoverable	NA	NA	Infinite	
Selenium, total recoverable	NA	55	Infinite	
Silver, total recoverable	NA	8.3	Infinite	
Sodium, total recoverable	NA	No Kd available	Infinite	
Thallium, total recoverable	NA	71	Infinite	
Vanadium, total recoverable	NA	1000	Infinite	
Zinc, total recoverable	NA	62	Infinite	

Table D-4. Input Parameters for VOCs

Volatile Organic Analytes	Koc (VOC) L/Kg	Kd[10] (VOC) L/Kg	T1/2 (VOC) Years	Cs (VOC) mg/kg
1,1,1-Trichloroethane	135	0.432	0.75	
1,1,2,2-Tetrachlororethane	79	0.2528	0.123	
1.1.2-Trichloroethane	75	0.24	1	
1,1-Dichloroethane	53.4	0.17088	0.423	
1,1-Dichloroethylene	65	0.208	0.5	
1,2-Dichloroethane	38	0.1216	0.5	
1,2-Dichloroethylene	65	0.208	0.5	
1,2-Dichloropropane	47	0.1504	3.5	
2-Hexanone	Not Available	#VALUE!	0.038	
Acetone	2.2	0.00704	0.019	
Benzene	61.7	0.19744	0.044	
Bromodichloromethane	55	0.176	0.05	
Bromoform	126	0.4032	0.5	
Bromomethane (Methyl bromide)	9	0.0288	0.077	
Carbon disulfide	54	0.1728	0.00934	
Carbon tetrachloride	152	0.4864	1	
Chlorobenzene	224	0.7168	0.411	
Chloroethane	15	0.048	0.077	
Chloroethane (Vinyl chloride)	8.2	0.02624	0.5	
Chloroform	52.2	0.168	0.5	
Chloromethane (Methyl chloride)	5.5	0.0176	0.077	
cis-1,3-Dichloropropene	27.1	0.08672	0.031	
Dibromochloromethane	107	0.3424	0.5	
Dichloromethane (Methyl chlo	10	0.032	0.077	
Ethylbenzene	204	0.6528	0.027	
Methyl ethyl ketone	4.51	0.014432	0.019	
Methyl isobutyl ketone	Not Available	#VALUE!	0.019	
Styrene	912	2.9184	0.077	
Tetrachloroethylene	265	0.848	1	
Toluene	140	0.448	0.06	
trans-1,3-Dichloropropene	48	0.1536	0.031	
Trichloroethylene	265	0.848	1	
Vinyl acetate	17	0.0544	0.0397	
Xylenes	238	0.7616	0.077	

Table D-5. Input Parameters for SVOCs

Semi-Volatile Analytes	Koc (SVOC) L/Kg	Kd[10] (SVOC) L/Kg	T1/2 (SVOC) Years	Cs (SVOC) mg/kg
1,2,4-Trichlorobenzene	1660	5.312	0.5	
1,2-Dichlorobenzene	379	1.2128	0.5	
1,3-Dichlorobenzene	1700	5.44	0.5	
1,4-Dichlorobenzene	616	1.9712	0.5	
2,4,5-Trichlorophenol	2365	7.568	1.89	
2,4,6-Trichlorophenol	1040	3.328	0.192	
2,4-Dichlorophenol	159	0.5088	0.192	
2,4-Dimethyl phenol	209	0.6688	0.192	
2,4-Dinitrophenol	0.03	0.000096	0.731	
2,4-Dinitrotoluene	95.5	0.3056	0.5	
2,6-Dinitrotoluene	69.2	0.22144	0.5	
2-Chloronaphthalene	48000	153.6	44.4	
2-Chlorophenol	398	1.2736	0.007	
2-Methyl-4,6-dinitrophenol	No Koc Available	#VALUE!	NA	
2-Methylnaphthalene	7940	25.408	0.132	
2-Nitrophenol	27	0.0864	0.077	
3,3'-Dichlorobenzidine	1550	4.96	0.5	
4-Bromophenyl phenyl ether	16,900	54.08	NA	
4-Chloroaniline	No Koc Available	#VALUE!	NA	
4-Chloro-m-cresol	66.1	0.21152	NA	
4-Chlorophenyl phenyl ether	7410	23.712	NA	
4-Nitrophenol	50	0.16	0.003	
Acenaphthene	4900	15.68	0.279	
Acenaphthylene	2500	8	0.164	
Anthracene	23,500	75.2	1.26	
Benzidine	11	0.0352	0.022	
Benzo(a)anthracene	358,000	1145.6	1.86	
Benzo(a)pyrene	969,000	3100.8	1.45	
Benzo(b)fluoranthene	1,230,000	3936	1.67	
Benzo(g,h,i)perylene	1,600,000	5120	1.78	
Benzo(k)fluoranthene	1,230,000	3936	5.86	
Benzoic acid	5.5	0.0176	NA	
Benzyl alcohol	6	0.0192	NA	
Bis(2-chloroethoxy) methane	7	0.0224	0.137	
Bis(2-chloroethyl) ether	76	0.2432	0.5	
Bis(2-chloroisopropyl) ether	61	0.1952	0.5	
Bis(2-ehtylhexyl) phthalate	111,000	355.2	0.063	

Table D-5. Input Parameters for SVOCs (continued)

Butylbenzyl phthalate	13,700	43.84	0.019	
Carbazole	3390	10.848	NA	
Chrysene	398,000	1273.6	2.72	
Dibenz(a,h)anthrcene	1,790,000	5728	2.58	
Dibenzofuran	9120	29.184	0.077	
Diethyl phthalate	82.2	0.26304	0.154	
Dimethyl phthalate	46	0.1472	0.019	
Di-n-butyl phthalate	1570	5.024	0.063	
Di-n-octyl phthalate	83,200,000	266240	0.077	
Fluoranthene	49,000	156.8	1.21	
Fluorene	7710	24.672	0.164	
Hexachlorobenzene	80,000	256	5.7	
Hexachlorobutadiene	53,700	171.84	0.5	
Hexaxhlorocyclopentadiene	20,000	64	0.077	
Hexachloroethane	1780	5.696	0.5	
Indeno(1,2,3-c,d)pyrene	3,740,000	11968	2	
Isophorone	46.8	0.14976	0.077	
m/p-Cresol	91.2	0.29184	0.079	
m-Nitroaniline	14	0.0448	NA	
Naphthalene	1190	3.808	0.132	
Nitrobenzene	119	0.3808	0.55	
N-Nitrosodiphenylamine	1290	4.128	0.093	
N-Nitrosodipropylamine	24	0.0768	0.5	
o-Cresol (2-Methylphenol)	91.2	0.29184	0.019	
o-Nitroaniline	38	0.1216	30.4	
p-Cresol (4-Methylphenol)	17	0.0544	0.002	
p-Nitroaniline	15	0.048	2030	
Pentachlorophenol	9055	28.976	0.488	
Phenanthrene	14,000	44.8	0.548	
Phenol	28.8	0.09216	0.027	
Pyrene	68,000	217.6	5.2	

Table D-6. Input Parameters for Pesticides and PCBs

Pesticides/PCBs	Koc (PEST) L/Kg	Kd[10] (PEST) L/Kg	T1/2 (PEST) Years	Cs (PEST) mg/kg
Aldrin	48,700	155.84	1.6	
alpha-Benzene hexachloride	1,760	5.632	0.37	
apha-Chlordane	51,300	164.16	3.8	
beta-Benzene hexachloride	2,140	6.848	0.34	
delta-Benzene hexachloride	6,600	21.12	0.274	
Dieldrin	25,500	81.6	3	
Endosulfan I	2,030	6.496	2030	
Endosulfan II	2,220	7.104	2220	
Endrin	10,800	34.56	10800	
Endrin ketone	No Koc Available	#VALUE!	NA	
gamma-Chlordane	51,300	164.16	3.8	
Heptachlor	9,530	30.496	0.015	
Heptachlor epoxide	83,200	266.24	1.51	
Lindane	20,000	64	0.658	
Methoxychlor	80,000	256	1	
p,p’-DDD	45,800	146.56	15.6	
p,p’-DDE	86,400	276.48	15.6	
p,p’DDT	678,000	2169.6	15.6	
PCB 1016	309,000	988.8	34200	
PCB 1221	309,000	988.8	34200	
PCB 1232	309,000	988.8	34200	
PCB 1242	309,000	988.8	34200	
PCB 1248	309,000	988.8	34200	
PCB 1254	309,000	988.8	34200	
PCB 1260	309,000	988.8	34200	
Toxaphene	95,800	306.56	6.35	

APPENDIX E

HUMAN HEALTH REMEDIAL GOALS

APPENDIX E HUMAN HEALTH REMEDIAL GOALS

This appendix provides the approach and methodology for calculating soil remedial goals protective of the future hypothetical industrial worker as part of this remedy.

1.0 CALCULATIONS FOR INDUSTRIAL WORKER EXPOSURE TO RADIONUCLIDES

The following two sections present a risk-based methodology and dose-based methodology (to show relevant and appropriate chemical -specific ARARs are met).

The values for radionuclide-specific parameters (dose conversion factors) are the same used in RESRAD, which are based on published values by the International Commission on Radiological Protection, US DOE, and the US EPA (JCRP 1979-1982; US DOE 1988a, 1988b; US EPA 1988). The radionuclide specific values are presented in Table E-1.

1.1 Risk-Based Remedial Goal (RG) Calculations

Recent guidelines from US EPA Region IV (US EPA 1995d) specify that remedial goal options (RGOs) may be calculated using one of two methods. A simplified method based an the ratio of the calculated risk to the target risk may be used, or RGs may be calculated in a more comprehensive manner where the risk equations are re-arranged and substituted with target risk levels to allow the back-calculation of a target concentration. Because the comprehensive approach provides a more thorough consideration of media and pathway-specific contributions to risk, this method is selected for calculating the RGs for the plug-in ROD.

The comprehensive approach used to develop these RGs includes (1) specific exposure factors such as intake rates and exposure frequencies as recommended by US EPA (1991), (2) standard EPA slope factors and reference doses, as specified by US EPA (1995 and 1996), and (3) target cancer and noncancer risk levels recommended by US EPA Region IV. Based on the location of plug-in candidate units in non-residential-use areas, the RGOs are based on the assumption of a future industrial worker land use scenarios, which is the most conservative of the non-residential land use scenarios.

The re-arranged risk equations used to calculate RGs are equivalent to those presented in the recent US EPA Region IV guidance (US EPA 1995d). These equations represent an extension of the approach used in *RAGS, Part B: Development of Risk-Based Preliminary Remediation Goals* (US EPA 1991b) and include consideration of site-specific exposure factors and the appropriate exposure pathways. Section 1.1.1 presents the specific equations used to calculate soil RGs for radionuclide constituents of concern (COCs); and Section 1.1.2 presents the equations used to calculate soil RGs for RGs for nonradionuclide COCs.

1.1.1 RG Calculations for Radionuclides

Risk-based RGs were calculated for soil to provide a comparison to the ARAR-based dose RGs. For each radionuclide, the RGOs corresponding to 1 x 10^{-6} is presented. The 95^{th} percentile of the background distribution for naturally occurring radionuclides is also provided for comparison (US DOE 1996). For some naturally occurring radionuclides, the background concentration is significantly higher than the 1 x 10^{-6} RG, and the background concentration would be used as the RG. The calculation considers intake from ingestion and inhalation exposure pathways, as well as direct exposure for the future industrial worker.

Radionuclide-Risk-Based RGs

$$RG = \frac{TR}{EF \times ED \times \left(\left(SFo \times IRo\right) + \left(SFi \times IRi \times CF1 \times \left(\frac{1}{PEF} \right) \right) + \left(SFe \times DE \times \left(1 - Se\right) \times CF2 \right) \right)}$$

where:

TR = Target Risk Level -- 1.0 x 10^{-4}, and 1.0 x 10^{-6}

EF = Exposure Frequency – 250 days/year

ED = Exposure Duration – 25 years

Sfo = Oral Slope Factor -- radionuclide specific

IRo = Oral Intake Rate – 0.050 g/day

Sfi = Inhalation Slope Factor -- radionuclide specific

Iri = Inhalation Rate – 2.5 m^3/hr

PEF = Particulate Emissions Factor – 4.63 x 10^9 m^3/kg (US EPA default)

CF1 = Conversion Factor -- 8.0 x 10^3 hr-g/day-kg

SFe = External Exposure Slope Factor -- radionuclide specific

DE = Direct Exposure Rate – 0.33 (8 hrs/ 24 hrs)

Se = Shielding Factor – 0.2

CF2 = Conversion Factor -- 2.74 x 10^{-3} years/day

Values for radionuclide-specific parameters are found in Table E-2. For those chemicals where toxicity values (e.g., inhalation slope factors) are not available, the relevant portion of the equation is omitted.

1.1.2 Nonradionuclide RGOs

Although radionuclides will be the remediation drivers for the candidate units for this plug-in ROD, a methodology for determination of RGOs for non-radionuclides is presented in order to ensure that risks are reduced to acceptable levels for all COCs. For nonradionuclide constituents, separate calculations are made target risk levels for both carcinogens and noncarcinogens, in accordance with US EPA Region IV recommendations (US EPA 1995d). The target excess cancer risk levels is 1 x 10^{-6}, and the target HQs (noncancer) is 1.0. Where background concentrations of naturally occurring metals exceed the target RGOs, background levels would be used as the RGO. The specific remedial goal (RG) for each COC should be determined for each specific unit, considering site-specific factors.

RGOs calculated for soil account for intake from the ingestion and inhalation pathways of exposure.

Carcinogenic-Risk-Based RGOs

RGO =

$$TR \times \frac{BW \times ATC \times CF1}{(EF \times ED) \times \left((SFo \times IRo) + \left(SFi \times IRi \times CF2 \times \left(\frac{1}{PEF} \right) \right) \right)}$$

where:

TR = Target Risk Level -- 1.0 x 10^{-4}, 1.0 x 10^{-5}, or 1.0 x 10^{-6}

BW = Body Weight – 70 kg

ATC = Averaging Time (Carcinogen) -- 25,550 days (=70 years)

CF1 = Conversion Factor -- 1.0 x 10^{6} mg/kg

EF = Exposure Frequency – 250 days/year

ED = Exposure Duration – 25 years

SFo = Oral Slope Factor -- chemical specific

IRo = Oral Intake Rate – 50 mg/day

SFi = Inhalation Slope Factor -- chemical specific

IRi = Inhalation Rate – 2.5 m^3/hr

CF2 = Conversion Factor – 8 x 10^{6} hour-mg/day-kg

PEF = Particulate Emissions Factor – 4.63 x 10^{9} M^3/kg (US EPA default)

For those chemicals where toxicity values (e.g., inhalation slope factors) are not available from the US EPA, the relevant portion of the equation is omitted.

Noncarcinogenic-Risk-Based RGOs

RGO =

$$THI \times \frac{BW \times ATN \times CF1}{(EF \times ED) \times \left(\left(\frac{IRo}{RfDo} \right) + \left(\frac{IRi \times CF2 \times \left(\frac{1}{PEF} \right)}{RfDi} \right) \right)}$$

where:

THI = Target Hazard Index (3.0, or 1.0)

BW	=	Body Weight – 70 kg
ATN	=	Averaging Time (Noncarcinogen) – 9,125 days
CF1	=	Conversion Factor -- 1.0 x 10^6 mg/kg
EF	=	Exposure Frequency – 250 days/year
ED	=	Exposure Duration – 25 years
IRo	=	Oral Intake Rate – 50 mg/day
RfDo	=	Oral Reference Dose -- chemical specific
IRi	=	Inhalation Rate – 2.5 m^3/hr
CF2	=	Conversion Factor -- 8 x 10^6 hour-mg/day-kg
PEF	=	Particulate Emissions Factor – 4.63 x 10^9 m/kg (US EPA default)
RfDi	=	Inhalation Reference Dose -- chemical specific

For those chemicals where toxicity values (e.g., inhalation reference doses) are not available from the US EPA, the relevant portion of the equation is omitted.

1.2 Dose-based RGO calculations

The remedial goal for cleanup of radioactively contaminated soils must consider existing relevant and appropriate requirements, as required by the National Contingency Plan [40 CFR 300.430 (e)(2)(i)(A)]. Three relevant and appropriate regulations were considered, including (1) 10 CFR 61.40 - NRC Requirements for Land Disposal of Radioactive Waste, (2) 10 CFR 20 - NRC Radiological Criteria for License Termination, and (3) R.61-63-Radioactive Materials.

NRC's Requirements for Land Disposal of Radioactive Waste (10 CFR 61.40) state that the maximum annual dose to the public shall not exceed 25 mrem to the whole body, 75 mrem to the thyroid, and 25 mrem to any other organ of any member of the public. This requirement is further specified in DOE Order 5400.5, Radiation Protection of the Public and the Environment, which states that exposure to the public to direct radiation or radioactive materials released shall not cause members of the public to receive, in a year a. dose equivalent greater than 25 mrem to the whole body. DOE Order 5820.2A, Low-level Waste Management, states that low-level wastes shall be managed to assure that external exposure to waste and materials released will not result in an effective dose of 25 mrem/yr to the public.

Similarly, the SCDHEC Regulation 61-63 Part VII, Licensing Requirements for Land Disposal of Radioactive Waste, 7.18, Protection of the General Population from Release of Radioactivity, is relevant and appropriate. Section 7.18 states that concentrations of radioactive material which may be released to the general environment in groundwater, surface water, air, soil, plants, or animals shall not result in an annual dose exceeding an equivalent of 25 mrem to the whole body.

Also, NRC's Radiological Criteria for License Termination (10 CFR 20) requires the licensee to meet a dose requirement in order to allow unrestricted use of a facility. Sec.20.1402 states "A site will be considered acceptable for unrestricted use if the residual radioactivity that is distinguishable from background radiation results in a TDE to an average member of the critical group that does not exceed 25 mrem per year, including that from groundwater sources of drinking water, and the residual radioactivity has been reduced to levels that are as low as reasonable achievable (ALARA)." US EPA does not consider the 25 TDE based on 10 CFR 20 to be protective enough.

Based on these regulations, 25 mrem/yr (as calculated based on 10 CFR 161.40) is used as the target dose equivalent. The calculations are performed to ensure the risk-based values are as low or lower than the ARAR-based values. The soil exposure pathway accounts for intake from ingestion, inhalation, and external exposure to radionuclides, as presented in the equation below.

Industrial Worker Dose-Based RGOs

RGO =

$$\frac{TDE}{\left(\left(EF \times CF1 \times DCFo \times IRo\right) + \left(DCFi \times DIFi \times \left(\frac{1}{PEF}\right)\right) \div \left(DCFe \times CF2\right)\right)}$$ where:

	TDE	=	Target Dose Equivalent (25 mrem/yr)
	$t_{1/2}$	=	half-life in years -- radionuclide specific
	CF1	=	Conversion Factor -- 1.0 X 10^{-3} g/mg
	EF	=	Exposure Frequency – 250 days/yr
	IR_o	=	Oral Intake Rate – 50 mg/day
	DCF_o	=	Oral Dose Conversion Factor-- radionuclide specific
	DCF_j	=	Inhalation Dose Conversion Factor -- radionuclide specific
	DIFi	=	Inhalation Dose Intake Factor – 5.0 x 10^6 m^3-g/kg-yr
	IR_i	=	Inhalation Rate – 2.5 m^3/hr
	PEF	=	Particulate Emissions Factor – 4.63 x 10^9 m^3/kg, default - US EPA 1991
	DCF_e	=	External Dose Conversion Factor -- radionuclide specific
	CF2	=	Conversion Factor – 1.0 g/cm^3
and	DIFi	=	IRi x ET x EF x CF3

where:

ET	=	Exposure Time – 8 hrs/day
CF3	=	Conversion Factor – 1 x 10^3 g/kg

The values for radionuclide-specific parameters (dose conversion factors) are the same used in RESRAD, which are based on published values by the International Commission of Radiological Protection, DOE, and US EPA (ICRP 1979-1982; DOE 1988a,b; US EPA 1988). They are presented in Table E-1. The 25 mrem/year TDE soil concentration equivalents are presented in Table E-2. Based on use of 1 x 10^{-6} risk-based soil concentration equivalents as the RG, as required by SCDHEC, Table E-2 shows that for all radionuclides the dose-based RGO is met.

2.0 REFERENCES

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Table E-1. Radionuclide Slope Factors and DCFs

Isotope		Half-life[a]	Slope Factors: Inhalation (Risk-pCi)	Slope Factors: Ingestion (Risk-pCi)a	Slope Factors: External (Risk/yr per pCi/g soil)	Dose Conversion Factors: Inhalation (mrem/pCi)	Dose Conversion Factors: Ingestion (mrem/pCi)	Dose Conversion Factors: External (mrem/yr per pCi/cm^3)
Actinium-228	c	6.13 h	3.27E-11	1.62E-12	3.28E-06	1.25E-04	2.16E-06	c
Americium-241		4.32 y	3.85E-08	3.28E-10	4.59E-09	4.44E-01	3.64E-03	2.99E-02
Americium-243	+D	7.380 y	3.82E-08	3.31E-10	2.66E-07	5.20E-01	4.50E-03	6.75E-01
Carbon-14		5730 y	6.99E-15	1.03E-12	0.00E+00	2.09E-06	2.09E-06	0.00E+00
Cesium-137	+D	30.2 y	1.91E-11	3.16E-11	2.09E-06	3.19E-05	5.00E-05	3.14E+00
Cobalt-60		5.27 y	6.88E-11	1.89E-11	9.76E-06	2.19E-04	2.69E-05	1.42E+01
Curium-243/244	b		2.89E-08	2.51E-10	1.71E-07	3.50E-01	2.90E-03	4.54E-01
Curium-243		2.85/E+01 y	2.89E-08	2.51E-10	1.71E-07	3.50E-01	2.90E-03	4.54E-01
Curium-244		18.1 y	2.43E-08	2.11E-10	2.07E-11	2.70E-01	2.30E-03	9.44E-04
Curium-245/246	b			3.35E-10	5.51E-08	5.40E-01	4.50E-03	3.43E-01
Curium-245		8.50E+03 y	3.92E-08	3.35E-10	5.51E-08	5.40E-01	4.50E-03	3.43E-01
Curium-246		4.750 y	3.92E-08	3.35E-10	1.89E-11	5.40E-01	4.50E-03	9.18E-04
Europium-152		13.3 y	7.91E-11	5.73E-12	4.08E-06	2.20E-04	6.00E-06	6.19E+00
Europium-154		8.8 y	9.15E-11	9.37E-12	4.65E-06	2.86E-04	9.55E-06	6.88E+00
Iodine-129		1.57E+07 y	1.22E-10	1.84E-10	2.69E-09	1.74E-04	2.76E-04	2.03E-02
Lead-212	c	10.6 h	3.85E-11	1.80E-11	3.00E-07	1.69E-04	4.55E-05	c
Neptunium-237	+D	2.14E+06 y	3.45E-08	3.00E-10	4.62E-07	4.90E-01	3.90E-03	1.01E+00
Neptunium-239	c	2.3 d	2.41E-12	4.27E-12	2.42E-07			c
Nickel-63		100 y	1.01E-12	5.50E-13	0.00E+00	6.29E-06	5.77E-07	0.00E+00
Plutonium-238		87.8 y	2.74E-08	2.95E-10	1.94E-11	2.88E-01	3.20E-03	9.75E-04
Plutonium-239/240	b		2.78E-08	3.16E-10	1.87E-11	5.10E-01	3.54E-03	9.25E-04
Plutonium-239		2.41+04 y	2.78E-08	3.16E-10	1.26E-11	5.10E-01	3.54E-03	5.09E-04
Plutonium-240		6.570 y	2.78E-08	3.15E-10	1.87E-11	5.10E-01	3.54E-03	9.25E-04
Promethium-147		2.62 y	7.49E-12	1.41E-12	6.35E-12	3.40E-05	9.50E-07	9.20E-06
Radium-226	+D	1.600 y	2.75E-09	2.96E-10	6.74E-06	8.58E-03	1.32E-03	9.69E+00
Radium-228	+D	5.76 y	9.94E-10	2.48E-10	3.28E-06	4.50E-03	1.20E-03	5.11E+00
Sodium-22		2.6 y	4.88E-12	8.02E-12	8.18E-06	7.66E-06	1.15E-05	9.62E-01
Stronium-90	+D	28.6 y	6.93E-11	5.59E-11	0.00E+00	1.30E-03	1.42E-04	0.00E+00
Technetium-99		2.13E+05 y	2.89E-12	1.40E-12	6.19E-13	8.33E-06	1.46E-06	1.05E-06
Thorium-228	+D	1.91 y	9.45E-08	2.31E-10	6.20E-06	3.10E-01	7.50E-04	8.31E+00
Thorium-230		7.70E+04 y	1.72E-08	3.75E-11	4.40E-11	2.60E-01	5.30E-04	1.32E-03
Thorium-232		1.41E+10 y	1.93E-08	3.28E-11	1.97E-11	1.64E+00	2.80E-03	8.35E-04
Thorium-232	d	1.41E+10 y	1.15E-07	5.12E-10	9.48E-06	1.95E+00	4.75E-03	1.34E+01
Thorium-234	c	24.1 d	1.90E-11	1.93E-11	3.50E-09	3.50E-05	1.37E-05	
Tritium		12.3 y	9.59E-14	7.15E-14	0.00E+00	6.40E-08	6.40E-08	0.00E+00
Uranium-233/234	b		1.41E-08	4.48E-11	3.52E-11	1.35E-01	2.89E-04	9.63E-04
Uranium-233		1.59E+05 y	1.41E-08	4.48E-11	3.52E-11	1.35E-01	2.89E-04	8.75E-04
Uranium-234		2.45E+05 y	1.40E-08	4.44E-11	2.14E-11	1.35E-01	2.60E-04	9.63E-04
Uranium-235		7.04E+08 y	1.30E-08	4.70E-11	2.65E-07	1.23E-01	2.66E-04	5.59E-01
Uranium-238	+D	4.47E+09 y	1.24E-08	6.20E-11	6.57E-08	1.18E-01	2.55E-04	7.94E-02

[a] Cancer slope factors and nuclear half-lives are provided in *Health Effects Assessment Summary Tables (FY-1995)* (EPA, 1995a)
[b] Where there are dual designations for cancer slope factors (e.g., curium-243/244), the most restrictive value for each exposure route was used in the calculation of the RTV.
+D includes short-lived daughters (half-lives less than or equal to 6 months)
[c] Included as daughter in decay chain of parent
[d] entire Th-232 decay chain aggregated, based on secular equilibrium in approximately 30 years.

Table E-2. Human Health Remedial Goals for Radionuclides

Isotope		Remedial Goal Option Industrial Worker 25 mrem/yr (pCi/g coil)	Remedial Goal Industrial Worker 1 x 10^{-6} (pCi/g soil)	SRS Background (95th %) (mg/kg)
Actinium-228	c			2.00
Americium-241		3.30E+02	7.67E+00	
Americium-243	+D	3.42E+01	7.62E-01	
Carbon-14		9.58E+05	3.11E+03	0.12
Cesium-137	+D	7.96E+00	1.06E-01	0.17
Cobalt-60		1.76E+00	2.27E-02	
Curium-243/244	b			
Curium-243		5.10E+01	1.17E+00	
Curium-244		8.37E+02	1.42E+01	
curium-245/246	b			
Curium-245		6.26E+01	2.77E+00	
Curium-246		4.35E+02	8.93E+00	
Europium-152		4.04E+00	5.42E-02	
Europium-154		3.63E+00	4.76E-02	
Iodine-129		1.05E+03	1.44+01	13.66
Lead-212	c	4.39E+04	7.34E-01	2.19
Neptunium-237	+D	2.36E+01	4.57E-01	
Neptunium-239	c		9.13E-01	
Nickel-63		3.46E+06	5.81E+03	
Plutonium-238		6.08E+02	1.03E+01	
Plutonium-239/240	b			1.14
Plutonium-239		5.55E+02	9.62E+00	
Plutonium-240		5.50E+02	9.65E+00	
Promethium-147		1.19E+06	2.12E+03	
Radium-226	+D	2.58E+00	3.27E-02	1.48
Radium-228	+D	4.88E+00	6.71E-02	2.42
Sodium-22		2.60E+01	2.70E-02	
Strontium-90	+D	1.40E+04	5.72E+01	2.08
Technetium-99		1.29E+06	2.27E+03	3.02
Thorium-228	+D	3.00E+00	3.56E-02	3.90
Thorium-230		3.09E+03	6.63E+01	1.64
Thorium-232		6.79E+02	7.20E+01	2.07
Thorium-232	d	1.85E+00	2.32E-02	
Thorium-234	c	1.46E+05	4.57E+01	
Tritium		3.12E+07	4.47E+04	
Uranium-233/234	b			
Uranium-233		5.47E+03	5.97E+01	
Uranium-234		5.82E+03	6.04E+01	
Uranium-235		4.45E+01	8.23E-01	0.09
Uranium-238	+D	3.02E+02	3.14E+00	1.34

[a] Cancer slope factors and nuclear half-lives arc provided in *Health Effects Assessment Summary Tables (FY-1995)* (EPA. 1995a).
[b] Where there are dual designations lot cancer slope factors (e.g.. curium-243/244), the most restrictive value for each exposure route was used in the calculation of the RTV.
+D includes short-lived daughters (half-lives less than or equal to 6 months)
[c] Included as daughter in decay chain of parent
[d] entire Th-232 decay chain aggregated, based on secular equilibrium in approximately 30 years.